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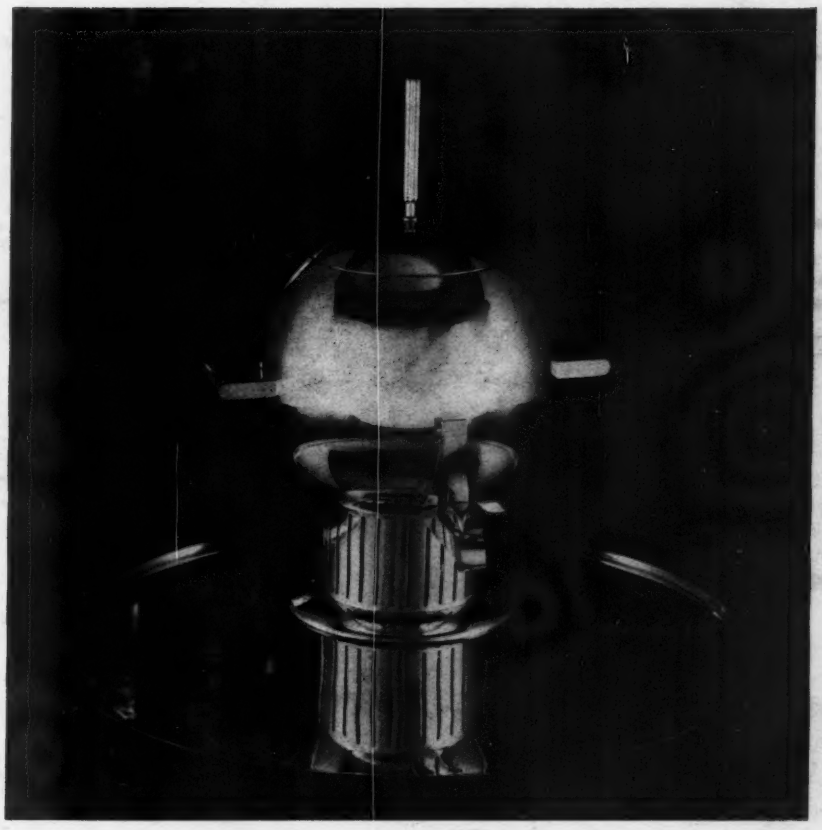

STACKS

*IN THIS ISSUE*

**Rocketry**

---

**Duprene — Synthetic Rubber**

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# . . . says Tokyo

Translating the symbols, the Tokyo telephone operator says, "The connection is made—go ahead, please." Meaning that now you can talk to Japan from any telephone in the Bell System.

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# OUR AUTHORS

**WILLIAM LESCAZE** was born in Geneva, Switzerland in 1896. His first architectural training was received at the Zurich Technische Hochschule under the able and wise guidance of Karl Moser.

Prior to 1929 two works of his stand out, although he was not very well known in his field. They are a New York bus terminal and the decorating of Leopold Stokowski's apartment in Philadelphia. The turning point was in 1929 when he associated himself with George Howe, who sees eye to eye with him on architectural design. Their first job together was the Oak Lane Country Day School.

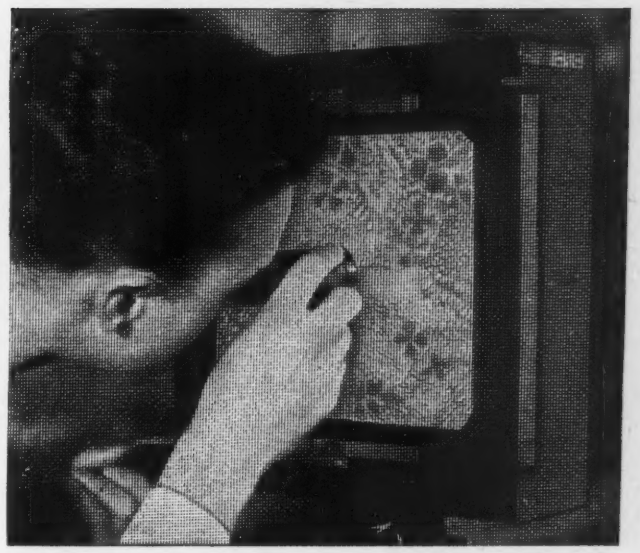
He is especially well-known for his excellent room interiors, notably the living room he designed for the Metropolitan Museum, in New York. On these pages he presents a description of his house in New York City. Interiors as well as the architecture, are entirely his design, with the exception of the piano and two plywood chairs which were designed by the Finnish modern architect, Aalvar Alto.

**G. EDWARD PENDRAY** who wrote "Rocketry, a New Field for Adventurous Engineers" was educated in Wyoming, receiving the A.B. degree at the University of Wyoming (Laramie) in 1924. He did postgraduate work at Columbia University (M.A. in 1925). He has been writer on scientific subjects for magazines for more than ten years and is one of the founders of the American Interplanetary Society (now American Rocket Society). He visited Germany, England, France and Italy in 1931 to study rocket research. Upon return to this country he organized and has since directed the American Rocket Society's research program, now the most ambitious and extensive in the world and was twice elected president of the American Rocket Society; he also served as editor of its publication, *Astronautics*. He carries on voluminous correspondence with rocket experimenters in America and abroad. He belongs to a number of organizations, among them the A.A.A.S., American Institute, American Public Health Association, Royal Astronoimcal Society of Canada, Bond Club (Harvard), etc. He is the author of: *The Earth Tube* (Appleton, 1929), and *Men Mirrors and Stars* (Funk & Wagnalls, 1935). The first is a novel of scientific background, the second a book on telescopes, and astronomy. *Men, Mirrors and Stars* was the Scientific Book Club selection for January, 1935, and is now selling 200 copies a week.

**REV. FATHER JULIUS A. NIEUWLAND,** the author of our article on DUPRENE was presented with the much-prized gold medal of the American Institute, one of the oldest awards in the United States. It was presented to Dr. Nieuwland of Notre Dame University, for the discovery of a process of making synthetic rubber. In addition to being a professor of organic chemistry, Dr. Nieuwland is a botanist. He started in 1904 to solve the chemical riddles involved in making artificial rubber, and today it is being introduced, as a factory-made product. *See Time, May 6, page 50.*

Dr. Nieuwland was born in Hansbeke, Belgium, in 1878, but grew up in the United States. He graduated from Notre Dame University and continued his studies at the Catholic University, where he received his Ph.D. in 1904.

**CARL M. LOEB, JR.** who wrote our article on MOLYBDENUM was born in 1904 in St. Louis, Missouri. He attended Princeton University where in 1926 he obtained his B.S., and then he took a post-graduate course at M.I.T. and there received his S.M. in course III in 1928. After graduating, Mr. Loeb entered the Metallurgical Research department of the Anaconda Copper Mining Co. Later he resigned to go with the Climax Molybdenum Co. where he is doing good work in Molybdenum research.

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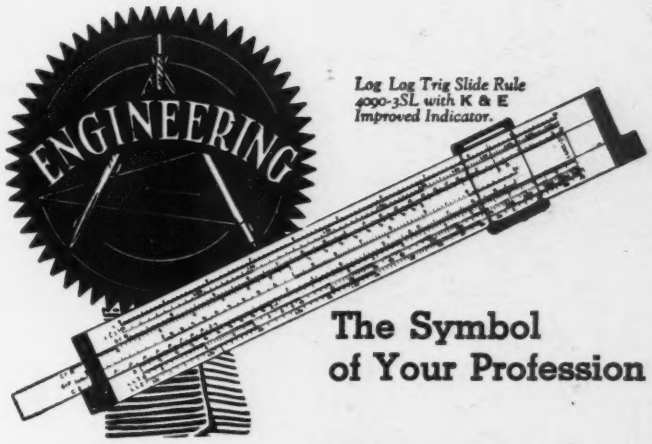


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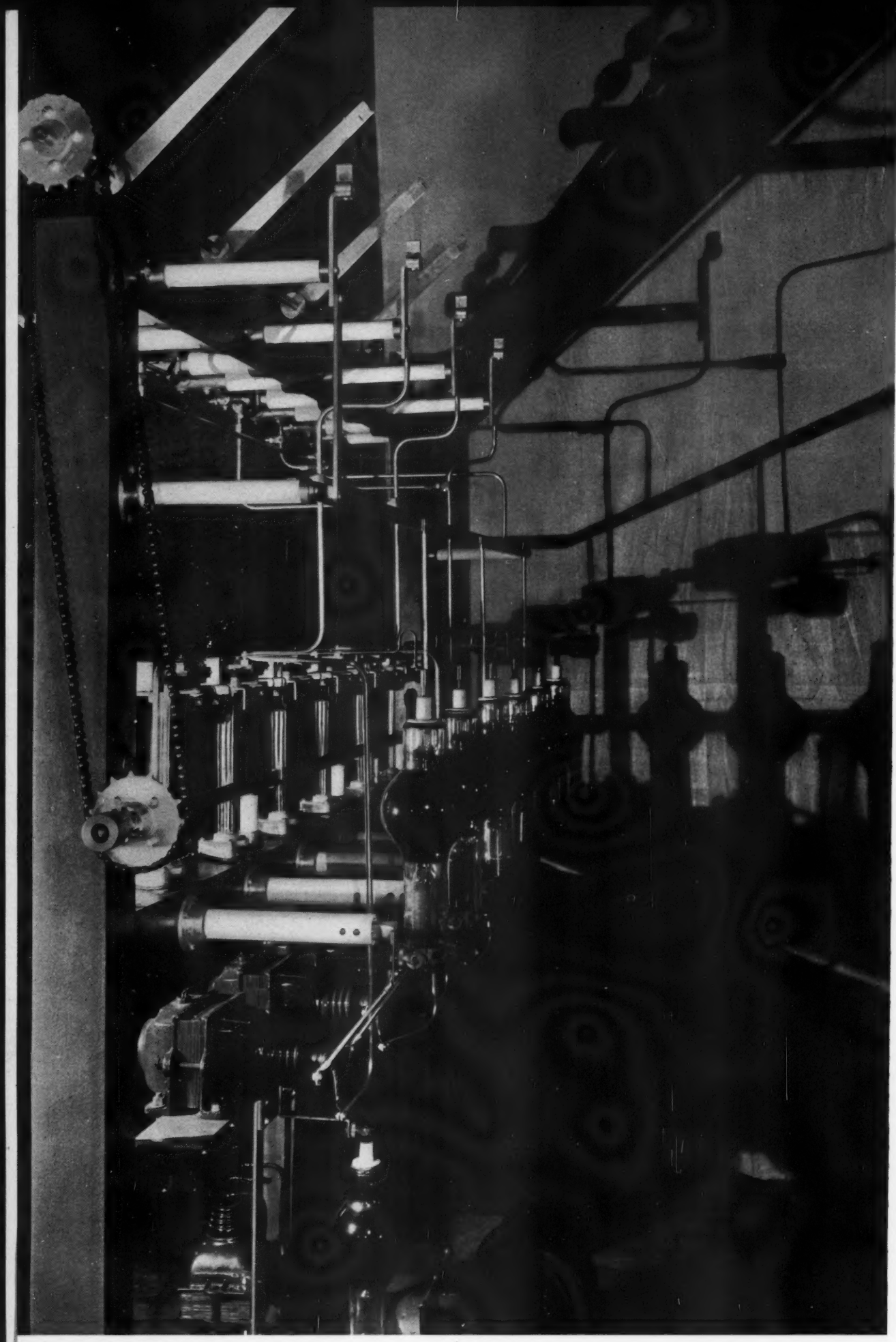

**BATTERY OF TUBES**

# THE TECH ENGINEERING NEWS

*JUNE, 1935*
*VOLUME XVI*
*NUMBER 4*

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DORIAN SHAININ
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*Editor-in-Chief*
ROBERT E. WILLIAMS, Jr.
*Business Manager*

*Technique*

# CITY HOME OF WILLIAM LESCAZE

*By WILLIAM LESCAZE*
*Architect*

MODERN architecture should always start from the intensive study of the requirements of the individuals who are to use the space to be enclosed; it should then concentrate on the creation of a plan which will meet all requirements, using the new materials and new methods of construction which have been thoroughly tested and which are within the budget of the individuals concerned.

*Architectural Forum*

The small New York City house was designed to meet the requirements and the preferences of my wife and myself within a rather limited budget. The general problem was to wrench from a small plot—16′7″ x 100′0″—the maximum of space for a home and a business, with the maximum of light possible in a city residence.

There are two entrances: one at the street level for the office; the other—up a short flight of stairs—for the home. At the side of the vestibule of the house entrance there is, flush with the wall, an aluminum hatch for package delivery, a service bell, and an eye-hole for the inspection of bell-ringers. Both front doors are of baked enameled steel.

The front facade is white stucco on brick, surrounding large areas of vacuum glass brick. On the top floor there is a solid wall of these glass bricks since that entire floor is a living room which is air-conditioned; the floor below has two opening windows set in the glass brick, since it is not air-conditioned. These vacuum glass bricks provide heat, cold, and sound insulation and cut off the image of the nine-story apartment house across the street.

The plan at the front is:—street floor—reception room of office; 2nd floor—kitchen and servant's room; 3rd floor—guest bedroom; top floor—living room.

The rear facade is of semi-glazed brick of two tones of grey. The windows are of plate glass. The curved section of the third floor wall reaches out and brings morning sun into the north bedroom, which is the master bedroom, since it is on the quieter side of the house. The plan at the rear is: street floor—drafting rooms and studio. These are housed in a story and a half extension which forms two terraces off the dining room, which is on the second floor rear; on the third floor, with the curved wall, is the master bedroom; and on the top floor is, again, the living room.

***Mr. Lescaze at home***

The extension roofs which serve as dining room terraces are of concrete with large areas of vault lights which give daylight to the drawing tables placed beneath them in the drafting room. Rush matting and lounging chairs are used on the concrete in warm weather. Flower boxes, a pool, and a birch tree are on the lower terrace.

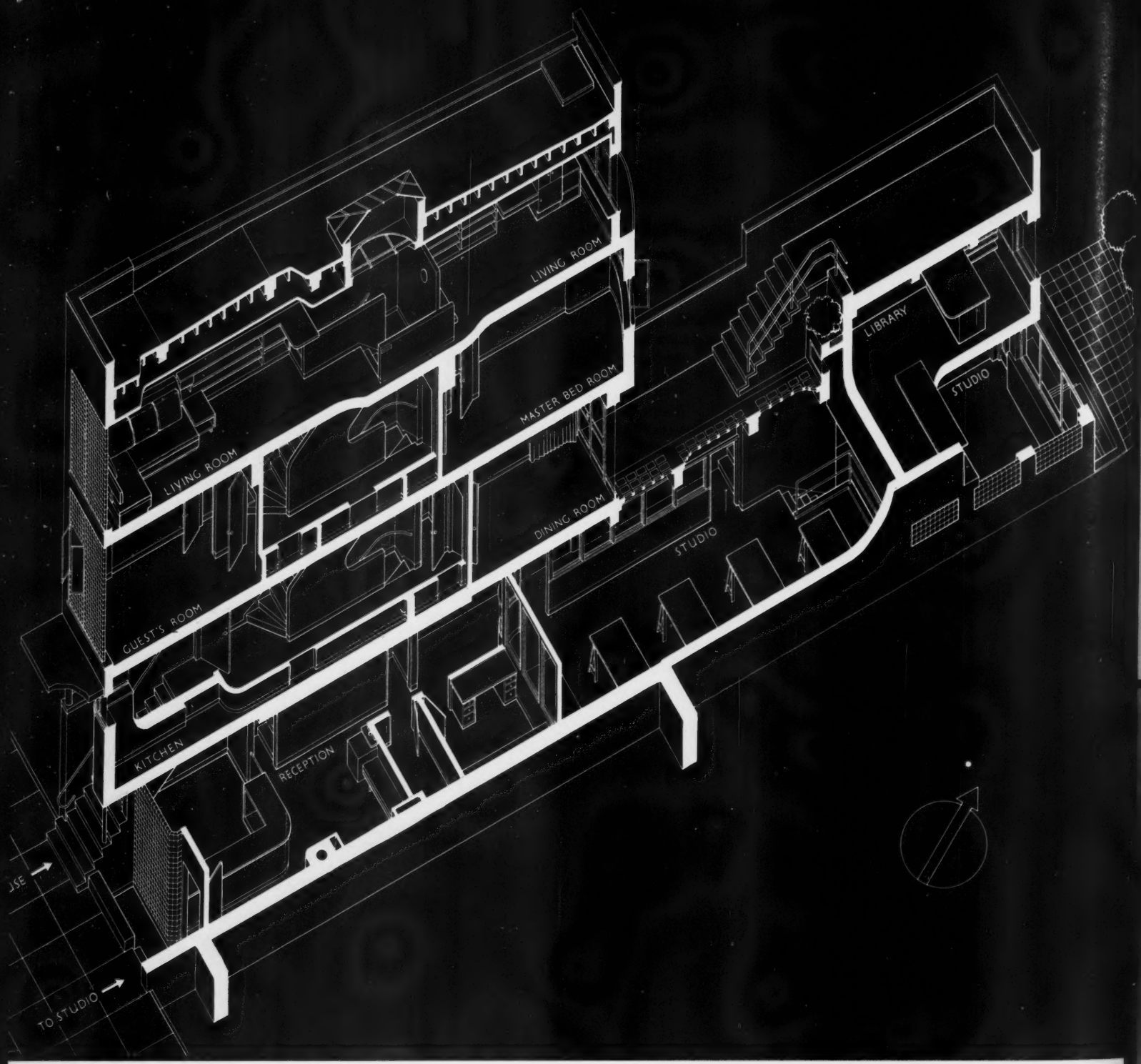
Only standard parts are used throughout the building—there are no specially designed window sizes, window handles, glass bricks, etc. That made for great economy. Steel window and door frames are used throughout the house.

The four major rooms—living room, master bedroom, dining room and the studio-office—are air-conditioned. That is, a complete system, cooling and dehumidifying in the summer and warming and humidifying in the winter. It is run in connection with an oil burner and compressors. All the ventilating and heating equipment for the living room is on the roof in a small machine room. The conditioned air is driven into the room through two circular baffles in the ceiling and goes out through a grille near the fireplace. Each of the other rooms mentioned has its own unit and each can be operated independently of the other.

The house was designed for simplicity in house-keeping and to be run with ease and efficiency with one servant. To help in this, though it is a small house (six rooms and three baths), there is a dumbwaiter and an inter-room telephone system; the air-conditioning reduces dust to a minimum; the metal used is non-tarnishable, and all the living room furniture has been treated with an alcohol proof finish.

Indirect lighting is used throughout. Color is applied to the walls either to bring out the contrasting architectural forms of the walls or to reflect or absorb the light properly. Colors do not follow an arbitrary scheme but rather my own preferences. All fabrics used are non-fadable. In the living room, soapstone is used for the fireplace since it is the most heat-resisting stone; and accoustic tile is used in the ceiling (as in the dining room where rubber tile is on the floor) to absorb some of the sound reverberations.

A gramophone-radio was assembled and installed by Barton Yager, sound engineer, with three loud speakers and three remote control boxes on the three home floors. Music can be played on all three floors simultaneously or on any one separately. Half of the living room carpet comes up for danc-




*rchitectural Forum*

ing on the waxed floor underneath.

All good architecture has been *living* architecture. It has been the modern architecture of its time, growing out of the life of its time, and fully aware of the requirements of that time. Use has been made of the materials available and of the known methods of construction. Forms have been erected with those materials according to those methods—forms beautifully appropriate to the requirements of that time.

This is true of all good architecture, regardless of the time in which it was born; the kind of requirements—temple, palace or cathedral; or the kind of materials—marble, stone or brick. And that is equally true today of good modern architecture.

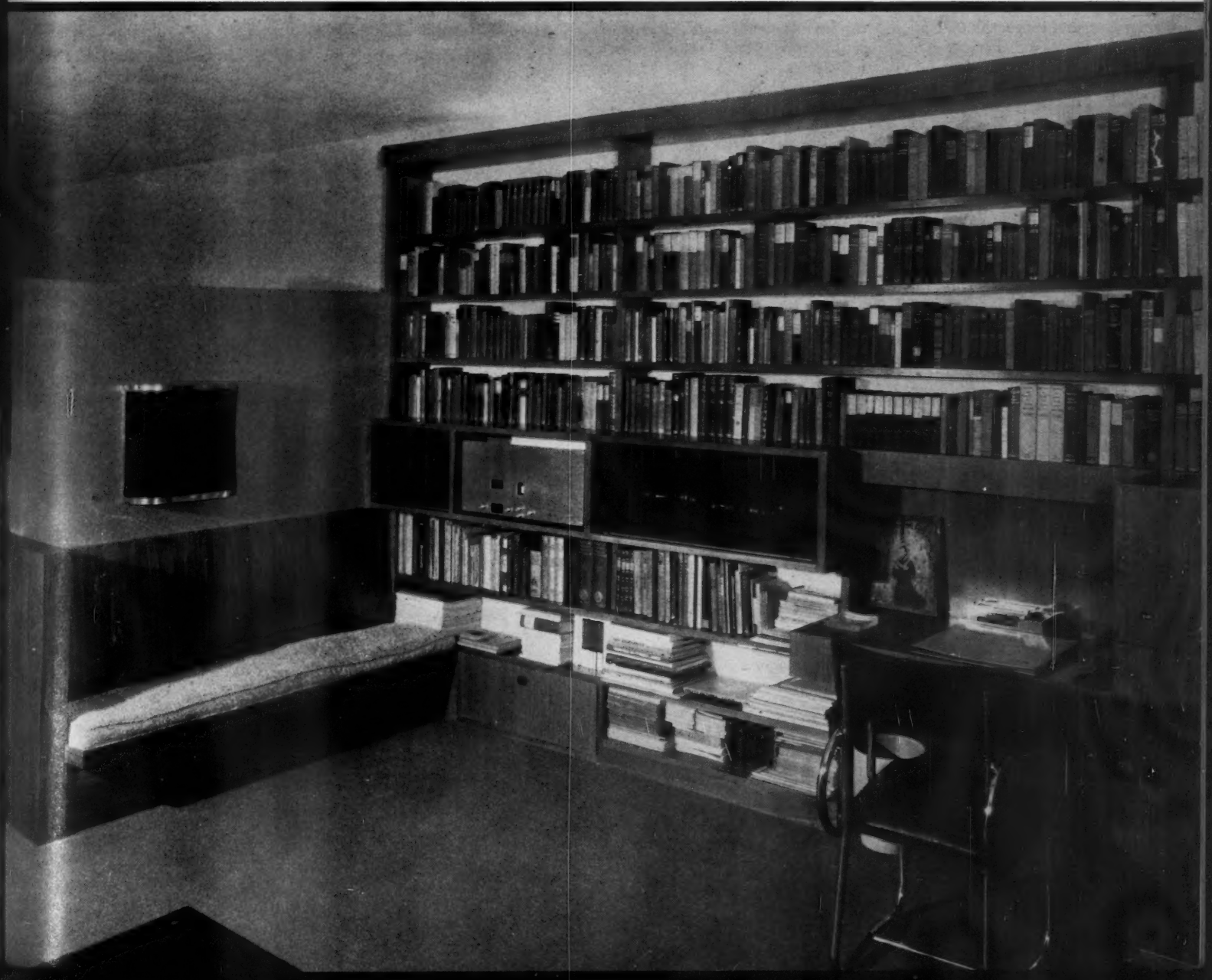
The approach to good modern design is the same in the field of industrial design of small articles as it is in the field of architecture. I think that the following remarks, written by Mr. Alfred Barr, Director of the Museum of Modern Art, New York, applies to both fields:—

> "Many objects—clock, chair, lamp—are the result of conscious artistic intention. For in a great many useful objects, function does not *dictate* form, it merely indicates form in a general way. The role of the artist (in machine art) is to choose from a variety of possible forms, each of which may be functionally adequate, that one form which is aesthetically most satisfactory. He does not embellish or elaborate, but refines, simplifies and perfects."

*Nearly all experiments in the United States with the modern forms of housing have been with detached units in suburban or country surroundings. It is interesting therefore to see what can be done with the conventional New York City brownstone front to make it conform with contemporary ideals of living. When, in addition, the house is the residence of the architect himself and also contains his workshop, it offers a case study of the greatest importance. it requires no prophet to see the great possibilities for the reclamation of much deteriorated housing if the slogan about walking to work can be amended to read, "walk downstairs to work." The section to the left shows the arrangement by which life and work are integrated.*

*Below is the north end of the living room. This part of the room, more or less separated from the other by the stairs, is the library as well as the working space for the mistress of the house. Here is the radio control which communicates with loud speakers in other parts of the house. This is also connected with the phonograph so that dancing can go on all over the house at the same time. The curved screen over the sofa conceals the loudspeaker on this floor.*





## *Research Has Put*

# MOLYBDENUM

## *on the Economic Map*

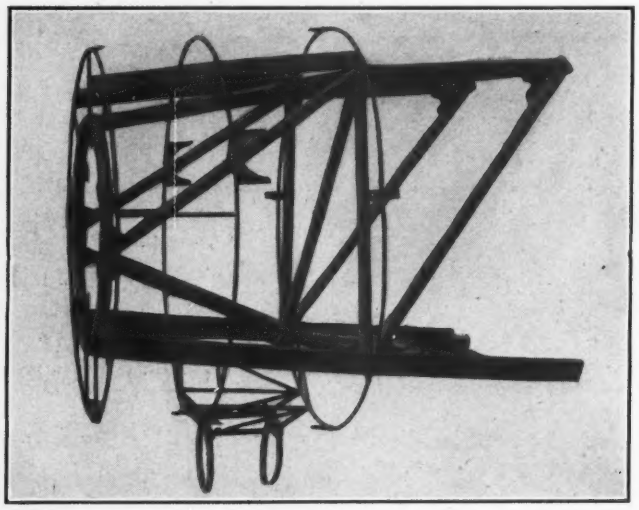
***By C. M. LOEB, JR., '28, M.S.***
***Metallurgical Engineer, Climax Molybdenum Co.***

WHEN Scheele's "Treatise on Molybdena" was published in 1778, little could be said on the subject except that there was a difference between graphite and molybdenum sulphide. When Hjelm produced metallic molybdenum, the achievement was regarded, and quite correctly so, as one of purely scientific interest. But the situation at the present time is quite different, even though only a few laymen know very much about the properties and uses of molybdenum.

Twenty years ago, only the metallurgical specialist in tool steel alloys was familiar with the possibilities of molybdenum as a steel alloying element. Ten years ago the use of the element in cast iron was a curiosity. But today extensive use is made of this element in compound form as well as a pure metal. The use of molybdenum has increased so rapidly since the World War, and is increasing so rapidly at the present time, that it is reasonable to believe that within a few short years, a good portion of the reading public will be familiar with at least the fundamental properties of molybdenum.

Molybdenum does not occur in elemental form in nature, and its compounds are among the more scarce constituents of the earth's crust. The minerals of most practical importance are molybdenite, $MoS_2$, and wulfenite, $PbMoO_4$. Molybdenite is sometimes associated with crystalline limestone or lime silicate rocks. It appears as black flakes with a blue luster and greatly resembles graphite with which it was formerly frequently confused.

Molybdenum is truly an American metal, for it is unique in that the largest known ore deposits of this metal are found in the United States. Although important deposits of molybdenite occur in Norway, Mexico, and Morocco, with some scattered Canadian deposits, the United States produces 80% of the world's consumption. Molybdenum is the only steel alloying element available within the borders of the United States in quantities sufficient to satisfy domestic requirements.



***The eighty-five pound engine mount carries a seventeen-hundred pound motor.***

Reliable data for estimating the world's output have only recently become available, but the following table which shows approximately the production for the world and for the United States for different years will bring out the dominance of the United States in this field.

POUNDS OF MOLYBDENUM

| Year | World Production | U.S. Production |
|---|---|---|
| Up to 1900 | 20,000 lbs. | Nil |
| 1920 | 300,000 " | 32,000 lbs. |
| 1930 | 3,600,000 " | 3,300,000 " |
| 1934 | 11,000,000 " | 9,000,000 " |

It is estimated that the largest ore body in this country contains at least enough molybdenum to supply an average of last year's U. S. demands for the next 250 years although the molybdenum content in ore is extremely low, only about 7 pounds of the metal being obtainable from a ton of ore. The element is marketed as calcium molybdate, the most commonly used form in steel alloys, at a price of $.80 per pound for the contained metal.

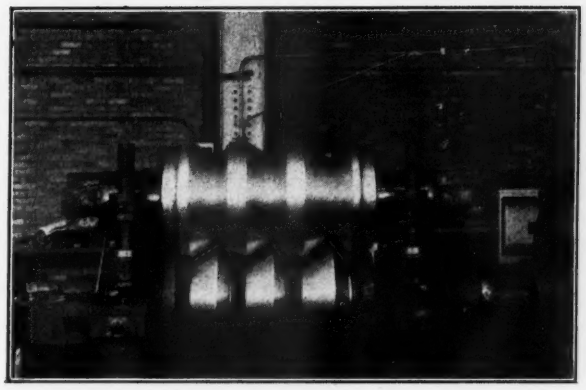
Molybdenum is reduced to elemental form as a powder, its high melting point of 2600°C making its production as molten metal impractical although not impossible. In 1907 it was discovered that by compressing the pure powder into bars at high temperatures, molybdenum could be hammered or swaged into wire and strip which could be drawn to very small gages. Metallic molybdenum is durable and tough at ordinary temperatures, and the wire was found to be useful as filament supports in electric lamps, although the metal is too volatile to be used as a filament in incandescent lamps. The metal resembles platinum in appearance although it is darker and possesses a peculiar luster. Despite its very high melting point, molybdenum alloys readily with iron or steel, the ferromolybdenum having a melting point of 1470°C. The metal resists acids and chemicals to a marked degree, takes up carbon, and, like iron, may be tempered and forged.

Molybdenum is said to be the only alloy metal used in steel which does not interfere with welding and is, in fact, claimed to be beneficial in this respect. Other physical and mechanical properties of molybdenum are given in the accompanying table together with data for some other metals for purposes of comparison.

PHYSICAL PROPERTIES OF SOME METALS

| Metal | Resistivity at 20° C. in $10^{-6}$ ohms-cms. | Temp. Coeff. x$10^{-6}$ | Spec. Grav. | Melting Point °C. | Ultimate Tensile Strength in $10^3$ lb. in$^2$. |
|---|---|---|---|---|---|
| Aluminum | 2.824 | 3.9 | 2.70 | 659 | 25–28 |
| Copper (annealed) | 1.724 | 3.93 | 8.89 | 1083 | 32–35 |
| Iron (wrought) | 10.0 | 5.0 | 7.86 | 1530 | 42–52 |
| Lead (cast) | 22.0 | 3.9 | 11.34 | 327 | 1.78 |
| MOLYBDENUM (drawn) | 5.7 | 4.0 | 10.2 | 2620 | 256–316 |
| Nickel (cold rolled) | 7.8 | 6.0 | 8.8 | 1452 | 75–171 |
| Silver (hard drawn) | 1.59 | 3.8 | 10.8 | 960 | 44–51 |
| Tantalum | 15.5 | 3.1 | 16.6 | 2850 | 132 |
| Tin (wrought) | 11.5 | 4.2 | 7.3 | 232 | 10 |
| Tungsten (drawn) | 5.6 | 4.5 | 19.0 | 3400 | 597 |
| Zinc | 5.8 | 3.7 | 7.1 | 419 | 17–43 |

Until the demand for molybdenum for the manufacture of special steels arose, the greater part of the world's output was



*Large angle chrome molybdenum finishing roller*

absorbed in the manufacture of a few chemical reagents. The first commercial steel application was probably in 1894 when steel containing molybdenum was made at the Creusot works of Schneider et Cie., from which rolled armor plate was produced. From that time until 1917 no extensive commercial uses of molybdenum steels was known, although a few tool steel makers used it in small quantities to improve the toughness of the high tungsten tool steels as early as 1900, and during the war, Germany was forced to substitute molybdenum in the manufacture of high speed tools because of a shortage of tungsten.

The birth of extensive commercial application of molybdenum steels and irons may be co-dated with the discovery of the extent of the mountain of molybdenum ore at Climax, Colorado, which was until that time an abandoned station on the continental divide at Fremont Pass, 11,500 feet above the sea level. The first commercial output of molybdenum from this mine was for a government contract in 1917 for use in Liberty motor crankshafts and Renault baby tanks.

The demand for molybdenum practically disappeared when the armistice was signed. The problem of developing the stable, useful, peace-time applications presented itself. The mine at Climax was shut down in 1919 and reopened in 1924 when the surplus molybdenum on hand had been sold, and the mine has been operating ever since. Several other molybdenum deposits have been developed since 1920, including mines in New Mexico, Norway, and Morocco. In addition, the Greene Cananea copper mine in Mexico is producing molybdenum as a by-product. The present world production is approximately that given in the accompanying table.

| Mines | Production in Pounds |
|---|---|
| Colorado mine | 8,300,000 |
| New Mexico mine | 700,000 |
| All other U. S. mines | 300,000 |
| Mexico | 1,000,000 |
| Norway | 450,000 |
| All other foreign mines | 200,000 |

The rapid development of the application of molybdenum has been based solely on its merits. Such a statement is most easily explained by the fact that before molybdenum steels were commercially available, the nickel, tungsten, and vanadium steel applications had been developed far enough to be standard practice. The use of molybdenum has often meant a replacement of part or all of some other alloying element on a cost or performance basis.

Molybdenum has a very definite purpose in all corrosion-resistant and stainless types of irons and steels. Of itself, molybdenum imparts individual and beneficial properties to both iron and steel, although it is generally conceded that the importance of the element lies in its remarkable ability to intensify the known effect of other constituents of alloys so that smaller quantities of some other alloying metal are required. In one case, for example, 0.2% of molybdenum replaced 1.25% of nickel and improved the properties of the alloy.

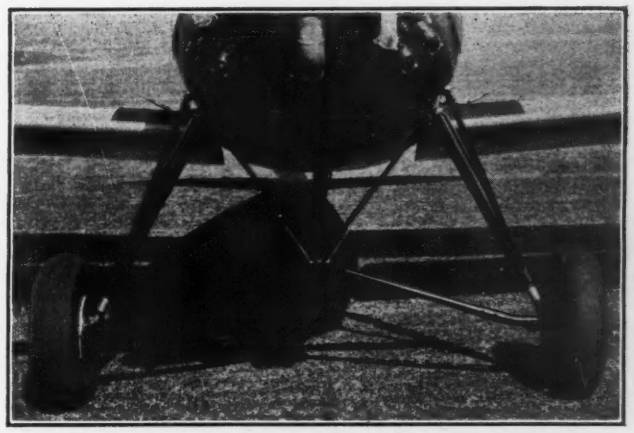
The use of molybdenum may be conveniently divided into the following groups.

1. Ferrous Products.
   - A. Steel.
   - B. Cast iron.
2. Chemical Industry.
   - A. Chemical compounds of molybdenum.
   - B. Colors and dyes.
   - C. Catalysts.
3. Pure Metal.
   - A. Radio tubes, filament supports, etc.
   - B. Elements in heating furnaces.

By far the largest proportion, probably 80%, is used in the iron and steel industry. Yet, recent developments indicate a more extensive use in the chemical field, and it is impossible to forecast how the percentage of consumption may change within the next few years.

When Mr. C. H. Wills began producing his "Wills Sainte Claire" in 1921, only two companies were using molybdenum steels commercially. Mr. Wills' automobile contained molybdenum in almost every moving part. The remarkable performance and speed of this car is still remembered although the company was dissolved in 1926. Since this initial experiment, other automobile companies have recognized the unique properties imparted by molybdenum and today we find some form of molybdenum steel or iron in every car. The more important automobile parts made of molybdenum include camshafts, drive rods, gears, axles, roller bearings, and many other parts and require outstanding physical properties being subjected to considerable wear.

The unusual merit of molybdenum in imparting strength to steel at high temperatures is well recognized in this country as well as abroad, and in this respect, the metal is successfully fulfilling an important service. Molybdenum alloys are being increasingly used to obtain thinner walls in high pressure boiler parts and, therefore, more efficient tubes with an equivalent or greater safety factor may be obtained. Diesel engines, oil-well equipment, machine tools, mining and road equipment, steel mill rolls, roller bearings, ship equipment, airplane engines, and other parts also represent some of the various uses to which molybdenum steels are being put. Molybdenum manganese rails have shown favorable results in careful service tests made over a number of years.



*Molybdenum alloy landing gear*

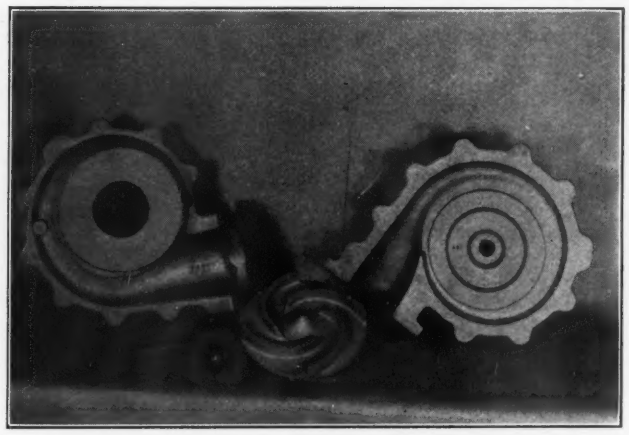
The use of molybdenum in cast iron, even as late as 1929 could hardly be classed as a sales outlet, but more than 10% of present sales of molybdenum in the United States are made for the use of molybdenum-bearing irons. The improvement in strength, toughness, resistance to wear and heat, which is so inexpensively imparted to iron by molybdenum has so impressed the foundry industry that the sales in cast iron have almost doubled every year since 1929 despite generally diminished business activity. Molybdenum has made it possible to replace steel castings and even forgings with cast iron. A list of its applications would fill a book; molybdenum iron is used in cylinder blocks, camshafts, steel mill rolls, brake drums, forging hammer frames, and abrasion resisting castings. These uses give some idea of its numerous applications.

The value of molybdenum in the form of ammonium molybdate for chemical analysis has been utilized for years. Sodium molybdate is successfully replacing the more expensive tungsten compound as a color base in inks. Patents covering molybdenum catalyzers to hasten chemical reactions have been recently noted. A most important development is the use of a molybdenum compound as a catalyst in the hydrogenation of coal. The process, now used in Germany, is under consideration in other countries seeking freedom from the necessity of importing petroleum and its products.

In 1929, it was found that photoelectric currents are produced by the action of the light from a quartz mercury lamp on molybdenum heated in a vacuum to 1325 C. The sensitiveness of the photoelectric effect increases to a final limiting value, and the limiting wave length is caused to shift from about 2600 to 3800 angstroms.

"Molybdenum has a very definite purpose in all corrosion-resistant and stainless types of irons and steels . . . The unusual merit of molybdenum in imparting strength to steel at elevated temperatures is well recognized in this country and abroad and in this respect the metal is successfully fulfilling an important service. Thinner walls, and therefore more efficient tubes with an equivalent or greater factor of safety . . . are indications of the magnitude of this field . . . Manganese molybdenum rails have shown favorable results in careful tests made over a period of years and the use of molybdenum steels is further indicated in other railroad equipment.

"Several patents have been taken out for the use of molybdenum filaments in the incandescent lamp industry . .



***Rayon pump parts of chrome molybdenum***

Preparations of molybdenum have been recommended for photographic work, in dyeing silks, woolens and leather and rubber; in the preparation of blue colors, and for producing red and yellow pottery glazes and glasses for coloring artificial emeralds; and as a catalystic agent in chemical operations molybdic acid has been tried as a depolarizing agent in place of nitric acid; various compounds are used as chemical reagents; and as a preservative for smokeless powder in hot climates. Molybdenum trisulphide has been recommended as a solder for lamp filaments. Molybdenum wire has been recommended as resistance wire in electric furnaces. It is used as a substitute for platinum and platinum-iridium alloys in various make and break contact devices; in dentistry; in the manufacture of X-ray tubes; and as a wire for supporting the filaments of incandescent lamps and as a support for refractory materials. The most important application of molybdenum is in the preparation of alloys and particularly of special steels — molybdenum steels. When compared with other alloy steels and tempered to the same tensile strength, A. H. Hunter said that molybdenum steels have a slightly higher elastic limit and elastic ratio; a higher elongation or greater ductility; and a higher reduction area of greater toughness."

The rapid development of the uses of molybdenum and its compounds and the extensive utility of the element assure its increased use and importance in the future.

***Rotary pot dyeing machines of molybdenum containing stainless steel***

## *Man Imitates Nature with*

# DUPRENE

## *— An Artificial Rubber*

*By REV. JULIUS A. NIEUWLAND*
*Professor of Chemistry, University of Notre Dame*

LAZINESS is the mother of invention. Of course, what is meant is physical laziness, and not mental laziness. The latter, in fact, will make one less a man. One need hardly comment on this statement because the history of science shows too numerous cases where time and labor saving devices resulted because someone was too lazy to do manual work, which, by the way, is the cheapest commodity in the world; otherwise, the "section gang" laborer would receive more wages than the "boss". The latter does the thinking; the former just moves dirt from hither to yon.

I have been asked times not a few what research is. I can think of no more adequate answer than that it is just thinking applied to the solution of a problem. There are perhaps three forms of research. You may find them even among janitors. One will be able to sweep a room in three of four broom strokes less than the others. If you study his work, you will find that he does not do it quicker because his brush or broom is broader, but because his mind is. Another will do the work better in a given time, and he too must use more brains to obtain results. A third will be too lazy to handle a broom and will invent a machine to do the work. One must then do something quicker or better than someone else, or do something fundamentally new. In any case, brains are needed for the result. In fact, I should have said rather the use of the brains one has, for too many people assume they have none and fail to use what they have. This is mental laziness and is most unforgivable in a human being who is normally constituted to think as naturally as to eat and sleep.

At the dawn of the human race, some say the Pleistocene Age, the human male forced the women to do all the hand work, because they did some head work. Since women think, such a state of affairs could not last long. Next, animals were made to do the drudgery. Since animals needed someone to think for them they were in time found to be too inefficient. A horse, camel, elephant or ox is stronger than man, but man finally found that he can obtain more (horse power) from a small machine. Perhaps this is the reason no one smiles any longer when he sees a horse driven to market in a truck. Thus the human race came from the Pleistocene Age to the machine Age.

The machinery of Chemistry is catalysis. Catalysis is cheap because there usually are no by-products that must be hauled away in a wheelbarrow. This process of manual labor costs too much money.

In the modern acetic acid process, acetylene is passed through an acidified solution of mercury salt, and acetaldehyde is formed. The acetaldehyde and air are passed through a catalyst ($V_2O_5$ or manganese acetate). Pure acetic acid is the result. The process is continuous and the intermediates are cheap. The catalytic reactions are cheap and efficient, but it costs money to haul away solid by-products. This same acetic acid can further be passed over lime to form acetone. The by-products are gas and water, and easily disposed of without expense. From this acetone catalytically, pinacol can be made and again catalytically dimethylbutadiene, which in thousands of pounds was made into German Methyl rubber during the War. It was bad rubber, and the process was abandoned in peace time. Moreover, as can be checked from the flow-sheet, the process was long, and it was difficult to control yields.

It may seem strange, yet another synthetic rubber, Duprene, better in many ways than the natural product, also begins with acetylene. Moreover, it can compete because of its unusual properties, with the best natural product. One of the first remarks I heard concerning it when it was first announced several years ago was, and for that matter a remark still made; namely, "Yes, it is better than natural rubber, but it is not rubber". This made me wonder who made the first definition of rubber, or why anyone, even now, has any right to make such a definition, inasmuch as we are still quite ignorant as to what rubber is. Someone analyzed the product from the tree and found it to contain only carbon and hydrogen. It is apparently a hydrocarbon. The unit particles of various synthetic rubbers, butadiene, isoprene, and dimethyl butadiene polymerize to form rubbers none of them as good as the natural; yet they are all hydrocarbons. In the rush for synthetic rubber, everyone tried to polymerize hydrocarbons with little success to be proud of. The history of the synthetic medicinals and dyes has shown the chemical world that we can make better drugs than nature, and more beautiful colors than are found in the rainbow or the flowers of the field. In making medicinals and dyes chemists found they could beat nature. In attempting to make rubber they seem to have been satisfied in trying to make something just as good, and when one does this, one usually obtains a poor imitation. The world does not want anything "just as good". It wants something better.

For a number of years we carried on a process at the University of Notre Dame which finally succeeded in making two very unsaturated hydrocarbons, namely, monovinyl acetylene ($H{=}C{-}CH{=}CH_2$) and divinyl acetylene ($CH_2{=}CH{-}C{=}C{-}CH{=}CH_2$), by passing acetylene gas into a solution or a sludge of cuprous chloride, water, and ammonium chloride. These substances acted as catalysts at ordinary temperatures and pressure. I may remark here that we might perhaps succeed quicker by doing more low pressure temperature catalysis. Unfortunately so little is known about catalysis that much of our present day work is largely empirical groping in the dusk. Not all of the biochemists or others may be able to tell us how a sunbeam with a few quarts of water and some carbon dioxide can make a bushel of corn. Some day we shall undoubtedly find out without being obliged to use big words like photosynthesis, etc., but then the world of tomorrow will have other and bigger problems. I have explained that our work in the preparation of Duprene consisted in the making of monovinyl acetylene. Divinyl acetylene can be made and is made at the same time. The genius and foresight of twenty eight chemists of the du Pont Laboratories finally solved the problem of adding to this M.V.A. (monovinyl acetylene) hydrochloric acid. The resulting substance B Chlorbutadiene polymerized six hundred times more rapidly than any other diene to a very superior rubber.

(*Continued on page 82*)

## *Engineers Find*

# ROCKETRY

## *a New Field*

***By G. EDWARD PENDRAY***
***President, American Rocket Society***

FROM a lonely spit of sand on the south side of Staten Island, overlooking Lower New York Bay, a slender tube of burnished metal flew skyward last autumn like a shaft of light. Bluish-yellow flame played about its midportion; the flight was accompanied by a roar that sounded like a combination of Niagara Falls and a steam whistle.

At an altitude of three hundred feet the projectile attained a speed of 600 miles an hour; at 400 feet it exceeded the speed of sound. Corkscrewing against the air pressures developing at its head, it swung in a wide trajectory over the bay, and landed about a mile from shore with a terrific splash, expending the balance of its energy in emitting a huge cloud of steam as the hot parts cooled.

It was rocket No. 4 of the American Rocket Society, first liquid fuel rocket to attain the speed of sound, and so far the record holder for rapid flight. This summer at Staten Island, and probably at half a dozen other places in the world, rocket builders will try to break the record, both for altitude and speed. Rockets are commanding attention today; engineers have begun to give them thought. It is not unreasonable to believe that we are nearing the dawn of a new age—one that will be as revolutionary as the era of the airplane.

In my opinion this is a field in which some young engineer of this generation will make an international reputation for himself. The groundwork of rocket research has now been laid by a long series of amateur experiments here and abroad. The rocket today is waiting for its James Watt, its Robert Fulton, or its Orville and Wilbur Wright.

*June, Popular Aviation* *Fletcher Pratt*
***G. Edward Pendray***

Some of the forthcoming geniuses of the new era may possibly arise from the ranks of men now in undergraduate work at the Massachusetts Institute of Technology. In any case, engineers should be acquainted with developments in this field, and for that reason I am appending herewith, at the invitation of the editor, a brief review of the rocket problem. It is necessarily incomplete and general, but interested engineers will find no difficulty in obtaining more concrete data from the American Rocket Society, of which most of the world's foremost rocket experimenters today are members.

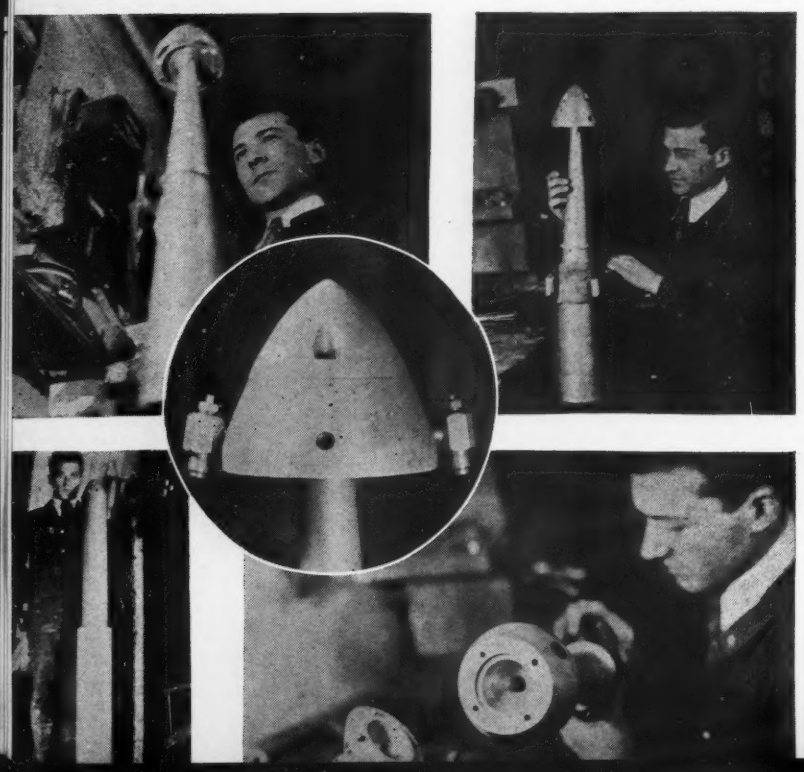
*1. What is a rocket?* It is a contrivance for transforming chemical energy into mechanical force without the interven tion (as in the gasoline engine, for example) of energy-consuming moving parts. The rocket works by reaction—the forward thrust of the rocket is equal to the mass of the ejected gas multiplied by its velocity. The efficiency of the rocket may theoretically approach 100 per cent, but only when the forward speed of the rocket is of the same order as the velocity of the escaping gas, which will be in the general neighborhood of a mile a second or more.

Contrary to a widely-held notion, the rocket does not progress by "pushing" against the air. The thrust is developed entirely within the combustion chamber and the nozzle, and is expressed by the well-known equation $MV = mv$; the mass of the rocket times its velocity being equal to the mass of the ejected gas molecules multiplied by their velocities. The reaction is strictly analogous to the recoil of a gun, which will, of course, kick in a vacuum as well as in air.

The rocket theoretically should be more efficient in a vacuum than in air, for the atmosphere impedes its forward motion, and also tends to retard the escape of gas from the nozzle. Actual experimental tests have demonstrated the advantage of shooting rockets in vacuo. Unfortunately, actual rockets must be started from or near the earth, and the effect of the atmosphere must be taken into account in all calculations of real rocket flights.

2. *What good are rockets?* The possibility that rockets may

*—Scientific American*



***Circle—Blast chamber and fuel inlet valves.***
***Upper left and upper right—Bernard Smith with motor assembly.***
***Lower left—The unfinished rocket.***
***Lower right—Looking into blast chamber toward nozzle.***

ultimately be shot away from the earth, and thus give us access to other planets, has been much talked about, with the result that the interplanetary angle has obscured the immediate and practical possibilities of rockets.

Most experimenters are agreed that rockets will be of extreme importance in the near future in stratosphere and upper atmosphere research. At this moment, rockets capable of making shots of five or six miles regularly, carrying instruments, would be invaluable in the air-mass analysis program being developed by the Weather Bureau. A little later, shots of ten to fifty miles should not be extraordinary, carrying along all of the expensive apparatus now sent aloft in costly stratosphere balloons. Parachutes or autogyro wings would bring these rockets softly to earth near the point of departure. Automatic radio equipment would guide the rocket in its upward flight, and enable ground operators to keep in touch with the projectile throughout its course and find it immediately upon its return to the earth.

The next step in the development of rockets would be shots from point to point, such as from Chicago to New York, or Boston to Philadelphia. At the speeds required for efficiency, these shots will require less than an hour each way, and should be capable of carrying mail and express in sufficient quantities to make the development of such rocket services pay.

At present, to be sure, almost nothing is known of the apparatus that would be necessary to control such rockets in flight or to land them safely in a given spot. Yet a year or so ago a young Austrian engineer had a paying mail-rocket project going between the small towns of Schöckel and Radegund, near Graz. He made more than thirty successful shots with mail, everyone of which flew on schedule and landed in the area prescribed, after a flight of about two miles over a mountain. Several systems of control have been worked out to the blueprint stage, but must await the construction of large enough rockets to carry them.

When rockets have been developed capable of control over short distances, the next step will unquestionably be shots across the ocean. These should take not more than two hours from Boston to Berlin, or New York to Paris. At a height of three or four hundred miles almost any speed will be possible, and the trajectories of transoceanic rockets should carry them to such altitudes over midocean.

Passenger-carrying rockets will probably not appear until all of these preliminary steps have been taken. There should not be any serious difficulty in adapting the express-rocket principle for passengers. Tests have shown that human beings are capable of standing accelerations of two or three gravity for brief periods without serious discomfort. This is all that would be necessary. The bulk of the flight would be made so high above the dense atmosphere that there would be no sound or jar whatever, and no power need be applied after the initial firing, except occasionally to correct the course.

Fantastic as it may seem, passengers could have breakfast in America and lunch in France. Coming the other way, passengers from Berlin would actually arrive in New York about four hours before they started, because of the difference in time.

*3. What are the principal parts?* A rocket consists of a blast chamber and nozzle (usually called the motor) in which the fuels are burned and from which the hot gas is ejected: tanks for carrying the fuels; apparatus for forcing the fuels into the blast chamber against pressure (this is usually accomplished in experimental rockets by putting gas pressure in the tanks); valves to control the fuel flow; aerodynamic surfaces, such as vanes, to keep the rocket on its course; a parachute or other landing apparatus, and an instrument compartment. These parts are arranged in a variety of ways; the best arrangement is still to be found, though experience points to the long, thin rocket with a sharp nose as best,

—*Scientific American*

***The first successful flight of a liquid fuel rocket in this country, near Staten Island. Mentioned in the text. Because of faulty design this rocket burst at an altitude of about 300 feet, after reaching a velocity of 175 feet per second.***

particularly for high speeds and long flights.

*4. What are rockets built of?* This is a field that needs considerable immediate research. At present most experimental rockets are made of aluminum alloys, though the successful No. 4 rocket of the American Rocket Society had copper tanks and an aluminum motor. The chief problem is the material of the motor, which must withstand temperatures approaching those of the oxy-acetylene flame, at pressures of twenty to fifty atmospheres. Fortunately, the period of firing is brief; this alone keeps the motors from burning out at once. Cooling water helps relatively little; it is changed to steam rapidly, and the interface between the metal and the water becomes vapor, without adequate cooling effect.

The problem of materials is now challenging the serious attention of most experimenters. Many different metals have been suggested, as well as ceramic materials. The testing of various types is slow, tedious, and unexciting; hence testing has not been as thorough as it should have been. This is a field that some young technologist might well select for special study; the tests could be made in a college laboratory—no shots would be required.

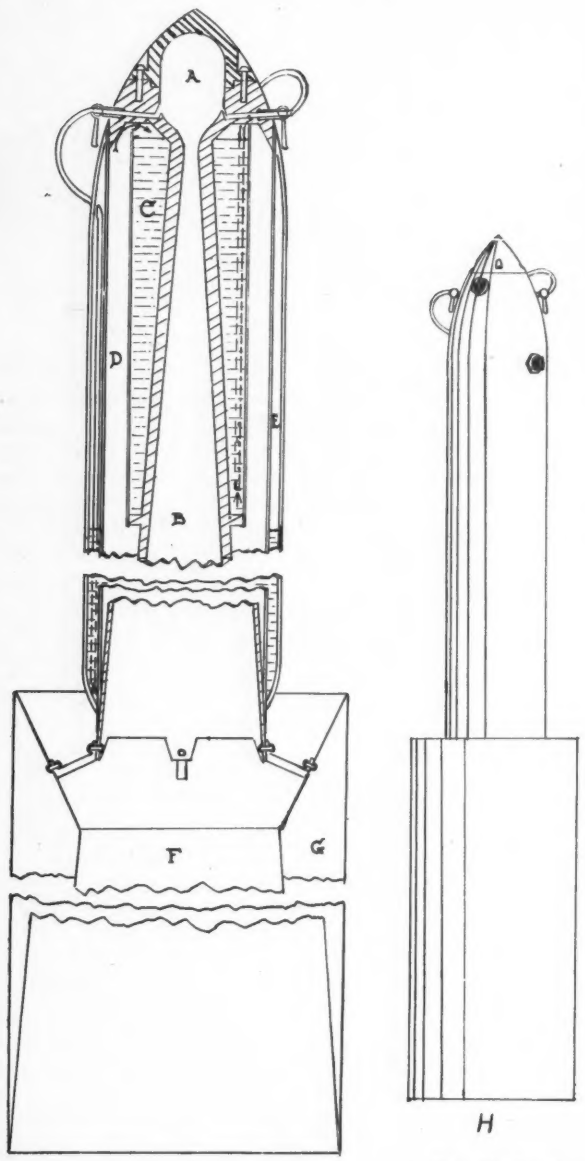
*5. What fuels are used?* One of the myths about rockets that popular writers have perpetuated is that the fuel problem is still unsolved. As a matter of fact, a number of readily available fuels give energy enough for their weight and volume to take care of all terrestrial flight needs. One of the most ordinary, and probably the best from a practical standpoint, is gasoline. This must be burned with liquid oxygen, which

is now rather costly, but will become considerably cheaper when a larger demand for it develops.

The fuels are carried in the rocket in separate tanks, for they form a violent detonating mixture. Separate feed tubes convey them to the rocket motor, where they are mixed and fired simultaneously. The result is not a single explosion, but a prolonged period of fierce combustion, varying in experimental rockets from twenty to thirty seconds. It will probably never be necessary to have rocket motors fire more than two or three minutes continuously.

Many other fuel combinations have been tried. Experimental as well as theoretical considerations have long ago ruled out so-called *dry* fuels, including gunpowder, chlorate and sugar, and other such combinations. They are impossible to control, are dangerous and apt to go off prematurely, and yield too little energy for their weight.

Next to gasoline and liquid oxygen in the favor of experimenters is alcohol and oxygen. Benzol and oxygen have been suggested, but few experiments have been made, chiefly because gasoline is cheaper and easier to get. Though alcohol theoretically would be more powerful than gasoline, it doesn't work out so in small test motors. Its principle advantage is that water may be introduced into the blast chamber with it, producing a cooling effect and thus making it possible for the motor to fire longer without serious erosion or melting. Liquid hydrogen and liquid oxygen have been suggested, but no practical shots have been made with this cantankerous combination; liquid oxygen is troublesome enough at the present stage of rocketry.




—*Scientific American*

***A rocket designed by Bernard Smith and the author. Height, 66 inches; weight, 20 pounds; thrust, 60 pounds. A, combustion chamber; B, exhaust nozzle; C, gasoline tank; D, nitrogen pressure tank; E, oxygen tank; F, thrust augmentor; G, parachute; H, exterior view.***

One of the problems connected with fuels is the matter of getting them into the combustion chamber rapidly enough against the explosion pressure developing there. In small experimental rockets this has been solved by putting nitrogen pressure behind the gasoline. The oxygen, once its tank is corked up, soon provides its own pressure, particularly if the tank is not heat insulated. In larger rockets it will probably be necessary to insulate the tank and force the oxygen into the chamber too, with nitrogen.

In practice, both fuels are put under the same pressure—say 300 pounds per square inch. The proportion of each to reach the blast chamber is regulated by the size of the respective inlet nozzles. The oxygen should reach the chamber in liquid form, if possible, and the fuels must be permitted to flow in with great rapidity. The pressure feed automatically regulates the pressure in the blast chamber, since the combustion pressure cannot rise above that in the tanks. If it does so momentarily, the fuels will stop flowing and the pressure will fall. Actually, in a properly designed motor, the pressures as between tanks and motor quickly reach an equilibrium. Experiments have shown the best fuel mixture to consist of two parts liquid oxygen to one part gasoline. An excess of oxygen is preferable, particularly in small motors, where the proper mixing of the fuels is difficult to achieve.

*6. What is the nature of rocket flight?* Accustomed as he is to vehicles of constant speed, driven by continuously operating engines, it is difficult to adjust the concept of the average engineer to the notion of a rapidly accelerated flight, followed by a long period of coasting on momentum. Yet this is the nature of rocket flight, and it cannot be otherwise. In vertical shots, the rocket must lift itself against the acceleration of gravity. If the motor were to have an upward thrust exactly equal to the weight of the rocket, there would be no flight; the apparatus would merely hang suspended in the launching rack.

For practical use, the thrust of the motor should be at least twice the weight of the rocket. This would give a *net* upward acceleration of one gravity, or roughly 32 feet per second. The rocket would then behave in the same manner as a falling body, except that it would fall upward.

However, as the fuel supply is used up, the rocket becomes lighter. Assuming that the rate of burning continues the same, the acceleration becomes greater, because the rocket weighs less. An acceleration of two to three gravity is most commonly obtained with small experimental rockets. In a vacuum such a rocket, firing thirty seconds, should make an altitude of more than fifteen miles. In air it would probably be four or five miles. At about the fifteenth second the apparatus reaches the speed of sound, when enormous head resistance sets in, and all of the conventional streamline methods used in air craft become useless. Thereafter the rocket must literally bore its way through the air; the chief considerations from an aerodynamic point of view being the cross section of the rocket body and the sharpness of the nose.

At the end of the firing period, the rocket continues its flight on its momentum, until the resistance of the air and the attraction of gravity use up its remaining kinetic energy. The proportion of free flight to powered flight in vertical shots within the atmosphere varies with circumstances, but may be roughly half of the total distance.

(*Continued on page 82*)

# HIGH SPEED ENGINES

*By RANDOLPH L. STRICKLAND '35*
***Massachusetts Institute of Technology***

BEFORE going very far into a discussion of High Speed Engines it might be constructive to make a few observations on what, in the past, have been considered high speed engines. The popular conception has been that all fast vehicles naturally have high speed engines to propel them, but this is erroneous. Not everyone knows that our fire-engines, aeroplanes, and some of our fastest speed boats have slow speed engines and that some of the fastest engines are on out-board-motor boats and sometimes auxiliary apparatus used in fire fighting. The engine in the average passenger car today is nearly twice as fast as those in the large transport passenger planes. A good deal of the confusion in this respect may be laid to the terminology, the term "high speed" as applied to engines meaning high number of revolutions per minute, and also to the fact that engines of high speed have a very definite purpose as do those of slow speed. For instance, an aeroplane propeller of the dimensions used today is no longer efficient if turned much over 2000 r.p.m. and marine propellers also have low critical speeds. On the other hand high speed has a definite purpose where high power output for small cylinder displacements is necessary. In this article I wish to point out the reasons for using engines of more revolutions per minute and briefly outline some of the disadvantages and problems associated with their development both from an engineering and practical standpoint.

It is quite obvious that having an engine turn faster, thereby making more revolutions in propelling a vehicle a given distance, will precipitate many new problems and disadvantages not associated with engines of slower speed. To begin with, it cannot be denied that an engine which is going to turn twice as fast as another will show more wear, but it will not be admitted that the wear will be twice as great, because other important factors enter which make the high speed engine practical at all. The fact of the matter is that more engine wear occurs when the engine is started up cold than at any other time because the oil has not had a chance to build up a film on the bearing surfaces and cylinder walls. On the other hand some bearings have been found in torn down engines which indicated that there had been no metal to metal contact during operation; bearings under these conditions would last indefinitely.

Realizing that all the moving parts go through more cycles in a higher speed engine, it cannot be overlooked that there will be more reversals of stress which cause fatigue cracks and eventual failures if the parts are not properly designed. Another difficulty is that the vibration caused by the shaking forces increases as the square of the speed. At one time this would have been considered an insurmountable barrier to higher speeds, but by careful analyzing of engine dynamics and balancing by means of counterweights, and also by reducing the weights of pistons and connecting rods, the forces have been controlled so that today engines are smoother in operations, when running twice as fast as were the engines of two decades ago.

In the foregoing I have mentioned but a few of the major difficulties which inevitably arise from increased speed. Ignition, valve timing, oil consumption and many other things also show strange behavior in the realms of higher speed. It might appear as the greatest folly to attempt many more strides in this direction. However engine speeds have been increasing every year.

With all the added worries of the engineer introduced by high speed, one is justified in questioning the practicability of this move towards higher speeds, and the possibility of the disadvantages outweighing the advantages. The most direct answer to the question "why high speed?" is that the only way to increase the power of an engine without increasing its size and weight is to increase the speed, assuming that all other power increasing methods have brought the engine to its peak of output. This takes us back to the relationship that Power = Torque $\times$ Speed. Torque may be increased by improving the combustion chamber design permiting higher compression ratios since torque is a function of b.m.e.p. (brake mean effective pressure in the cylinders). But this increase in torque of necessity means increasing the size of the parts which are to transmit the torque, starting with the crankshaft back through the clutch, gear box, driveshaft, differential, axel shafts to the wheels. This added weight is not at all desirable in the cars today designed and fashioned as they are, particularly since a good percentage of the added weight is bound to be what is termed "unsprung weight" which, specifically, is the rear axel, and in cases of a torque tube drive, the drive shaft. On the contrary it will be noted from statistics that power output has been increasing faster than engine sizes. The results of more "horse power per cubic inch of piston displacement" while not having been obtained solely through higher speeds but also through improved combustion chamber and general design, will, in the future, depend more upon higher speeds because of the high state of the art of combustion. Although there is very little known about the actual combustion process, engineers have succeeded in making use of it, the "art" mentioned being practised empirically to the greatest extent. Horse power per cubic inch has seldom if ever been used in the past as a selling point for automobiles. What made it important and of considerable interest were the automobile races conducted under official rules and supervision (in this country by the A.A.A.) Each year the speeds of the cars increased until finally the rules were made to specify definite limits for engine size, using piston displacement as a basis for this measurement. The racing cars' speed continued to increase although the rules each year specified smaller and smaller engines until they got down to a size about one third the size of the smallest popular car sold in this country and developing about one and a half times the power. This was accomplished mainly by increasing the engine speed until speeds of 8000 r.p.m. were attained and would carry a car through the gruelling 500 mile race at Indianapolis. This is double the speed at which most of the engines in the 1935 stock models reach their power peak and about four times that reached by American airplane engines. Today high speed comes to the fore because of the present tendency to cut down on weight. More attention is being paid today to new and improved weight distribution. Cutting down on all car weights, particularly the engine, will aid in this move considerably.

How may high speeds be attained and what is the limit? If power and friction curries were plotted, when the power curve of the engine crosses the friction curve of the engine,

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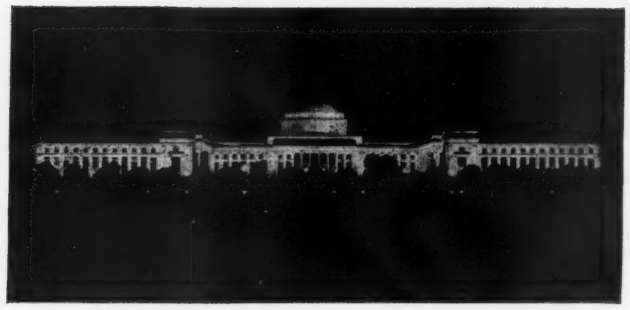


# EDITORIALS

## *COTTON PICKER*

IN a recent issue of *Time* there was published an account of a new cotton-picking machine together with a brief review of the cotton industry. In 1792, two years before Eli Whitney patented his cotton gin, cotton production amounted to four thousand bales. Ten years later production had increased to 96,000 bales. By 1835 it had passed the million mark and today it stands at 12,000,000 bales annually. Such an increase in production was, of course, not caused solely by the cotton gin; parallel development in carding, spinning, weaving, and transportation were of great importance. Nevertheless, the cotton gin furnished the original impetus.

Cotton picking, however, has remained unchanged. Negroes still do the picking by hand, gathering about one hundred pounds per day per laborer. For eighty years men have attempted unsuccessfully to perfect a mechanical picker that would gather the cotton without hurting the plants or collecting rubbish. Several years of experiment by two Texans have finally yielded a machine that will pick as much cotton in seven and a half hours as a man can pick in eleven weeks. The machine is said to do an efficient job at an operating cost (including repair, fuel, labor, and interest) of ninety eight cents per acre of cotton. Planters estimate that, were the price of cotton to fall below five cents per pound (the present price is twelve cents per pound), production would still be profitable.

The invention of a cotton picking machine is only one of a great many inventions which cause a social problem, but it is an important one in that it will effect a very large industry. Should the machine prove successful, it will cause thousands of men to be thrown out of work. It will tend to load more heavily an already overloaded market. Yet the machine cannot be legislated out of existence any more than inventiveness can be so legislated.

In 1794, Whitney's cotton gin was welcomed by a small industry that was struggling for its existence in a new country where labor was scarce. It was born into an era of unsaturation. Today, the cotton picking machine is born into an era of near-saturation. New and different conditions obtain, and they require a new and different treatment of the matter. More properly, the matter requires treatment. In 1794, there was no problem of what to do with the cotton gin; the path was obvious. Today, however, it is necessary to make allowance for the new economy of saturation. The saturation is an equilibrium point whose balance is infinitely delicate. Whether by legislative control or by whatever control seems best, there must be some conscious effort at direction and planning.

## *ANNOUNCEMENT*

The managing board takes pleasure in announcing the following elections to the editorial department: Frank B. Kemp, '38 and Dale F. Morgan, '38 to the positions of assistant managing editors, Arch H. Copeland, '38, James B. Hess, '38 Harry O. Saunders, '38 Frank S. Gardner, '38 to the positions of assistant editors.

## *PLANNING*

WHEN a college student gets to his junior or senior year, he finds himself meditating now and then upon what life will be like when he is out in the world working. Who is going to employ him? What type of work will it be? Will he actually spend his spare hours in an attempt to obtain gainful knowledge? Will he really be conscientious at his work?

At best, the answers are merely speculative. Planning to take the best advantage of future spare time and opportunities is well meant but often without fruitful results. However, his likes and dislikes are not speculative, and some thought concerning what sort of an atmosphere he is going to surround himself with when he is no longer to live at a fraternity house, dormitory, or home with his parents, will be a planning of a very definite sort that will affect his future environment, assuming that his likes and dislikes remain unchanged.

The house he would like to live in will, no doubt, require that he have a considerable income—one large enough to discourage many from thinking further about the matter, but planning might possibly be the cause of a large income.

Planning was never the cause of failure. "Crossing your bridges before they are built" is not a bad idea at all. Incentive is a force which urges, and it originates solely from planning. A well-earned and satisfying success can come from incentive planning. A view of what the modern trend seems to be in houses is offered on these pages as a starter.

You, as that college student, could easily form some definite ideas about the layout of your home to be, the style of furniture, and on possibly the manner in which you want inherent comfort in both appearance and experience. The rather appealing interiors, unusual exteriors, and an emphasis upon smoothness rather than angularity and pomposity throughout might possibly make you a bit envious of your future life. Plan yours tonight, and yours will be the enjoyable evening.

## *THE RELATIONSHIP OF PHYSICS TO ENGINEERING*

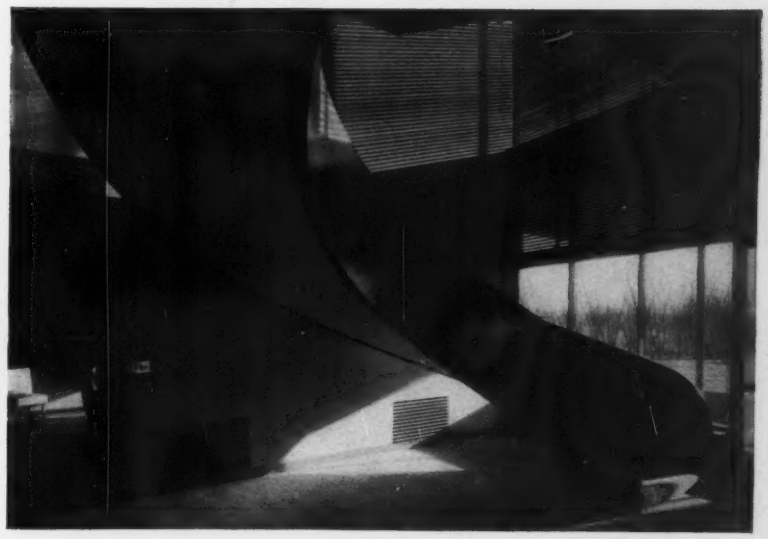
ENGINEERING curricula may, in general, be divided into two parts, a basic general training and special professional courses. At the Institute, the basic training lasts for two years, the courses taken by all students being essentially the same. In the second year there are some differences for different courses, but the instruction is of such a fundamental nature (in contrast to the specialized professional subjects) that it may properly be included as part of the basic training. In this two-year period of basic work, physics is allotted more time than any other subject, and the question naturally arises, "Why is physics so important for all the engineering and technical courses?"

In formulating an answer to this question we may well direct our attention, in turn, to the past, the present, and the future. The latter, of course, is more or less a matter of speculation, but there are certain trends which seem to indicate some of the aspects of the future of engineering. From the history of the development of our modern technical civilization we learn that the very origins of engineering lie in the study of physics. We may point to Lord Kelvin, a great physicist, whose activities in connection with the transatlantic cable development must be classed as an outstanding engineering achievement. Application of physical principles and methods to practical problems forms the starting point of engineering applications, and indeed physics may be regarded as the mother of engineering. For example, the course in Electrical Engineering at the Institute had its beginnings as an option in Physics. Of course, the child has outgrown the parent, at least in size. In this connection it is perhaps unfortunate, as President Compton has pointed out, that the various engineering professions are denoted by names which do not always bring out clearly their intimate connection with physics. Just as Chemical Engineering consists essentially of applying the fundamental principles and methods of chemistry to technological and engineering problems, so might we equally have the name of "Physical" Engineering for our engineering courses, since they do consist essentially of the application of fundamental physical principles and methods to special problems.

From the standpoint of the present, we must again emphasize the fact that the basis of all engineering lies in the principles of physics and chemistry. The scientific aspect of this work is identical with that of physics and chemistry. Of course, there are aspects of engineering quite foreign to the fundamental sciences; for example, the economic problems arising in industrial applications. We may well compare the steps in the education of an engineer to the corresponding steps in the construction of a building. The foundation of our building has its counterpart in the study of physics, chemistry and mathematics. And although it is not particularly inspiring to construct the foundation when one is anxious to reach the higher stories of a building, no one will deny that the number of stories one can build is strictly limited by the foundation. The skyscraper must have a rather different sort of foundation than an ordinary dwelling. If students of engineering would continually keep in mind the fact that their ultimate progress in their chosen fields is limited by their fundamental scientific knowledge, they would never look upon

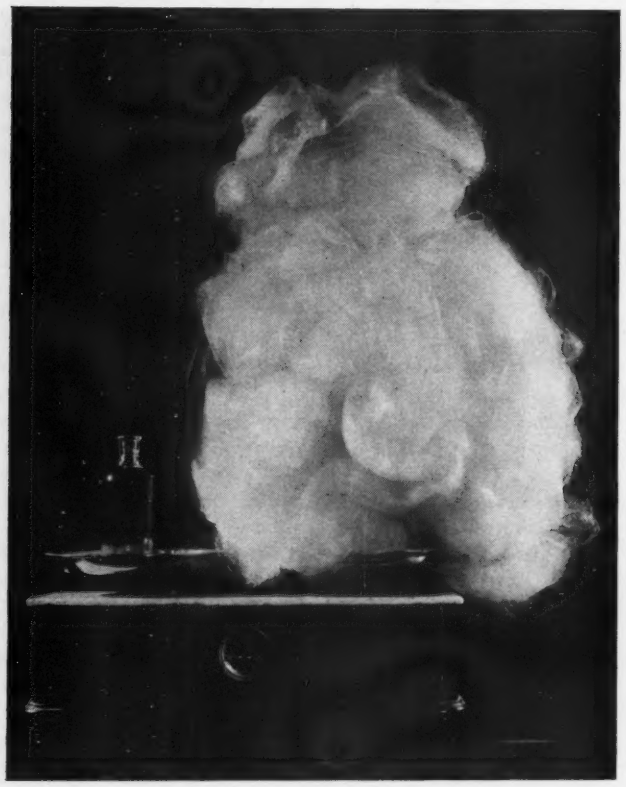
(*Continued on page 84*)

*Architectural Forum*



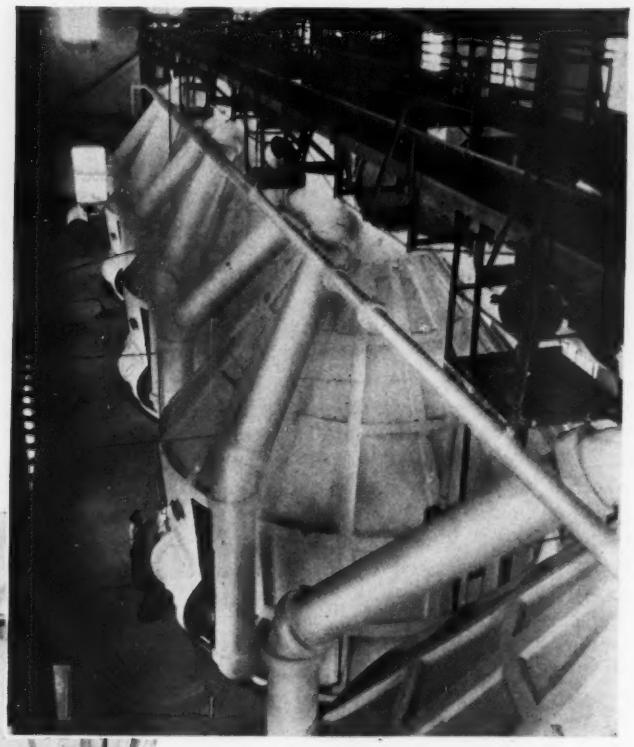
"... *modern trend in houses.*"

# ENGINEERING DIGEST



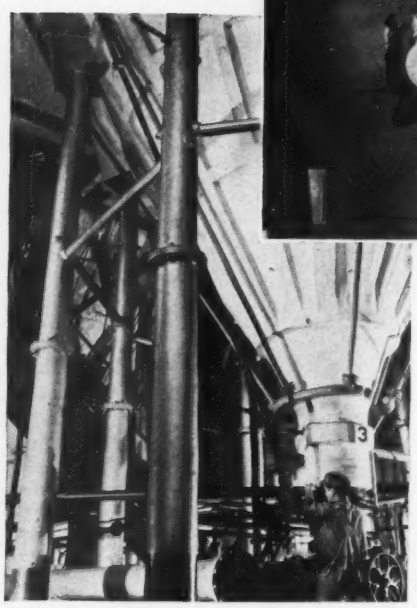
## GLASS WOOL

THE use of spun glass as an insulator in refrigerating has been discovered highly practical. A bat of glass wool matted together in the form used in insulation seems to conform well to the general specifications applying to any good insulation and in particular, it has the special characteristic which must be present in insulation in the refrigeration field. Of these last special characteristics its immunity to effect from moisture as to loss in insulating coefficient or permanence of material is most marked. The accompanying illustration shows the relative volume of the wool as compared to an equivalent weight of glass in an ordinary bottle. — *Refrigerating Engineer*



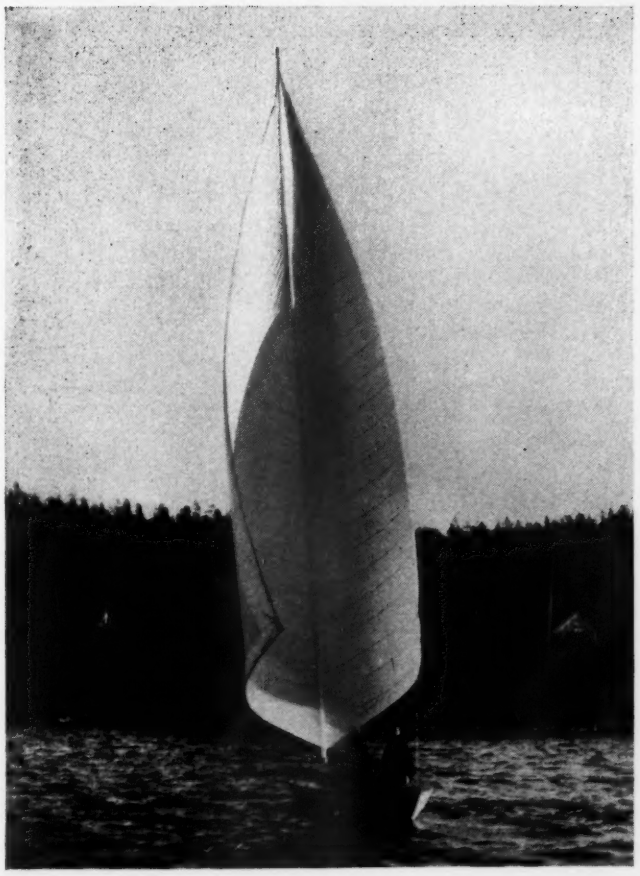
## PURE SALT

IN the recovering of salt from brine, two methods have been found successful—vacuum pans and grainers. The latter, which are open vats constructed of a low copper steel painted with a resistant finish, are long, shallow pans equipped with steam coils placed 6 inches above the bottom. By proper control of the temperature uniform crystals may be produced. As these are formed they drop to the bottom and are raked to the front end by a series of slow motion mechanical rakes faced with Monel metal; the lips of the grainers are also covered with the same corrosion-resistant alloy. The former method, however, has been found to give a salt crystal of greater purity, luster, and fineness of grain than was formerly thought possible. The latest development of this method are the quadruple-effect evaporators shown here in their top and bottom views. These are large cylindrical vats 65 ft. high and 22 ft. in diameter with a daily capacity of 800,000 lbs. of salt. The flue sheets and pans of the bodies are of iron construction and the tubes are copper. Because of the rapidity with which salt crystallizes in these evaporators, fine crystals are formed which distinguish vacuum pan salt from that made by other processes.



For the production of the free running grade of salt for household use choice runs of the best quality salt are weighed into large mixers equipped with revolving blades where 1 per cent by weight of tricalcium phosphate is added. To produce the iodized salt, tricalcium phosphate containing potassium iodide is used, so that the final product has .02 per cent potassium iodide.

A high degree of purity of the product is further attained by employing mechanical handling throughout the process and by the use of construction material resistant to the corrosive action of the hot and cold brine solutions.—*Chemical and Metallurgical Engineering*



## HIGH SPEED SAILBOAT

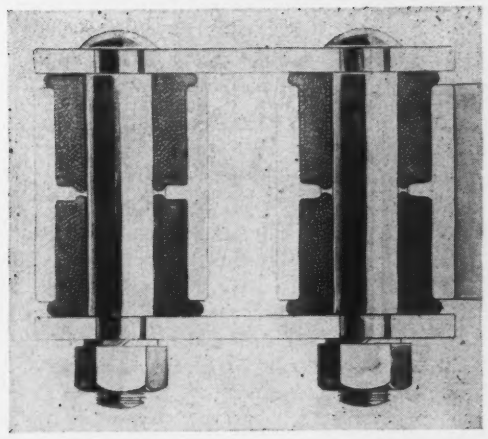
THE above boat has caused much discussion among sail boating experts. With no fore sail or boom, only one mast stay, and a mast which rotates on roller bearings, this new creation is so fast that it has beaten several much larger and more complicated rivals. To reduce sail area, as is usually done by reefing, the navigator simply turns a wheel at his elbow in the cockpit and rotates the mast by a system of ropes. Aerodynamic streamlining is achieved in the sail by having its forward edge fixed in a slot on the bow side of the 46 ft. pine mast. — *Scientific American*

## SHAPES

EVEN such an apparently insignificant thing as electrical appliance cord is now available in a new shape to fit in with the modern idea in homes. The insulation around each wire is hexagonal in form and it comes in any of four colors to match the scheme of the particular room it is used in. —*Simplex Wire and Cable Co.*

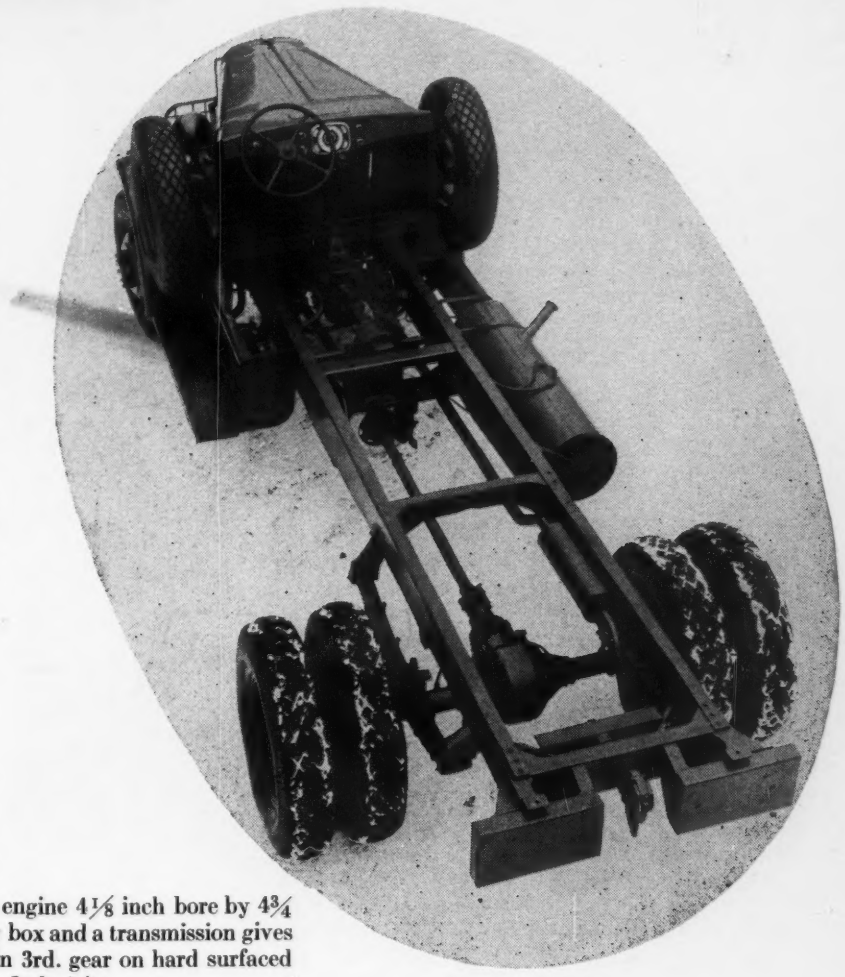
## FOUR WHEEL DRIVE TRUCK

IN compliance with the rigorous specifications issued by the U.S. Army engineers, the last word in army transport efficiency has been built. The four wheel truck pictured has a gross weight rating of 14,500 lbs. and is powered by a six-cylinder engine 4⅛ inch bore by 4¾ inch stroke. In addition, the use of a transfer box and a transmission gives it the amazing grade ability of 57 per cent in 3rd. gear on hard surfaced road with 14,500 lb. gross load.— *Automotive Industries*



## RUBBER SHACKLES

PROBABLY one of the greatest reasons for hte efficiency and economy of the modern automobile is the prominent use of rubber in its construction. No longer can one sit down and count on his fingers the parts of rubber built into the automobile, for the number of parts made of rubber or of composition are amazing. It is now used as an anti-friction agent, a beautifier of the exterior a substitute for interior springing of seats, and a wonderful all-around eliminator of vibration and noise. A typical example of a new use of rubber in the modern car is the rubber shackle which has entirely eliminated squeaky springs and dirty grease.— *The Rubber Age*



# RESEARCH IN REVIEW

## ENGLISH AND HISTORY

THE present economic crisis has focused attention on the relations of science and technology with society at large. Understanding of these can be had only when the historical background of the problem is presented; unfortunately materials for such presentation are lacking. Research now in progress in the Department of English and History, it is hoped, will help fill this void. Most of the projects may be grouped generally as social history.

The late President Maclaurin's contributions to the Institute, both scholarly and material, well known to earlier generations of Technology men, will be preserved for the future in Professor Pearson's full-length biography. Mr. Bartlett is treating a cognate subject in his analysis of the first American attempts at formal engineering education. That the engineer has made valuable contributions to literature appears in Mr. Eaton's forthcoming study of this subject. Professor Fassett is continuing his history of newspapers in the State of Maine, carrying the work down to 1860 and thereby opening a much-neglected field of journalism.

Economic history is closely related to the history of science and technology. In this field Mr. Lawrence is writing a book on the early history of the oil industry, utilizing, for the first time, much material on the first New York and Pennsylvania wells and the development of refining. Another phase of this industry is treated in Mr. Watson's researches into whaling and aspects of the maritime history of Massachusetts. Professor Fassett is also studying the glass industry. The origins of the American city, physical, economic, racial and cultural, will be reviewed in Professor Bridenbaugh's *Rise of the Colonial Towns, 1625-1776.*

*The Cult of Stability, 1715-1740* is Professor Roberts' contribution to the twenty volume history, *The Rise of Modern Europe,* edited by William L. Langer. This study will treat all aspects of European life in this period.

## COURSE XVI — Aeronautics

One of the newer fields of research in aeronautics is the analysis of the air reactions on a body whose attitude to the wind direction is unsteady, such as the lift, drag and moment on a fluttering wing. All varying air reactions due to unsteady attitudes are associated with a varying circulation around the body whose phase lags behind, and whose amplitude falls short of, the static or steady attitude values. The determination of the phase lag and the amplitude factor is necessary to an analysis of unsteady air reactions. To make an experimental approach upon this problem apparatus is now under construction which will permit the measurement of the instantaneous air reactions on an airplane wing model which is forced to execute a few simple kinds of translational or rotational cyclic motions in the wind.

A number of related studies have been pursued by the aeronautical laboratory, directed at the rationalization of the behavior of air-actuated instruments. A test chamber has been constructed, in order to subject the instrument to known pressure variations and thus measure its equivalent mass and damping factors. From this data, the lag characteristics and amplitude reduction factor are determined and the behavior of the instrument under any service conditions can be foretold.

## COURSE V

RECENTLY, from the Research Laboratory of Organic Chemistry, has come the important announcement of what is known as a total asymmetric synthesis or, in other words, the synthesis of an optically active compound from optically inactive ones. In the Journal of the American Chemical Society for February, 1935, Professor Tenney L. Davis, '13 with Robert Heggie, '33, has described experiments showing how an unsaturated (ethylenic) compound, 2, 4, 6-trinitrostilbene to be exact, can add bromine while being irradiated with right circularly polarized light of wave length 3600-4500 A°, to form an optically active (dextrorotatory) derivative. It appears that only one other total asymmetric synthesis has ever been reported, although many partial syntheses of this type have been successful.

Chemists have been studying the phenomenon of optical rotatory power intensively ever since 1848 when Pasteur demonstrated the existence of dextro- and laevo- rotatory forms of tartaric acid and postulated that unsymmetrically built molecules were the source of the optical activity. A great many laboratory syntheses, aimed at the production of optically active compounds, have yielded only inactive ones. Nature, on the other hand, often produces either pure dextrorotatory compounds or pure laevorotatory compounds.

The new synthesized compound, reported by Davis and Heggie, has the unfortunate property of gradually decomposing and slowly losing its ability to rotate a plane of polarized light. However, the search for other and more stable optically active compounds, formed by the same method, is being carried out. Further successes will have an important bearing on understanding just how nature produces her asymmetrical molecules and, as well, on clarifying theories of syntheses in the laboratory.

## COURSE VII — Biology

THE Course VII program of student and staff investigations comprises an assortment of problems. These include the measurement of active oxygen in the fat of milk subjected to commercial ultra-violet irradiation; the culture of organisms from the malady called "athletes foot"; and the discovery that the hair of a man or the fur of a cat make excellent food for these bugs. Other subjects being investigated are the edibility of the canned dasheen, a semi-tropical root which makes excellent French-fried "potatoes"; the study of land isopod populations in artificial climates simulating the tropics and the antarctic type of weather; and a qualitative analysis of the protoplasms of bacteria, grown to different patterns from a common ancestry. The accurate measurement of carbon balance in the life chemistry of certain fungi as an aid to their classification, and the precise evaluation of ultra violet light from a large quartz monochromator in the cure of rickets, also form a part of the research program. There is being developed a systematic body of fact on the histology of Norwegian White Rat of which some twelve thousand specimens have passed through the rat laboratory without anyone knowing the intimate details of their cellular architecture. The perennial problem of what's in a cup of coffee has taken on new interest with the construction of a large micro-apparatus. In this apparatus ten pounds of coffee are extracted in a continuous flow process, the concentrate appearing at the end of the Lilliputian still as a drop or two of smelly fractionated distillate.

## COURSE I — Civil Engineering

A LARGE scale model of the Cape Cod Canal and Buzzards Bay is being built by the staff of the River Hydraulic Laboratory. The United States Army Engineer Corps is to enlarge the canal to a surface width of 700 feet and a depth of 40 feet. To study the effects of the larger section, an exact replica of the Canal as well as of Buzzards Bay and of Cape Cod Bay will be built, the model to occupy a space about 115 feet long with Buzzards Bay alone requiring a space of 35 by 50 feet. The model scale is approximately nine feet to the mile.

Mr. Ruge has started construction of a new shaking table for producing artificial earthquakes. Previous research had demonstrated the need for a shaking table which can reproduce motions of arbitrary character. The new table was designed under the direction of Dr. Vannevar Bush, Dean of Engineering.

Graduate thesis research problems now under way in the Soil Mechanics Laboratory include: an investigation of the distribution of surface stresses under a circular footing on cohesionless material; a study of the lines of flow and the drawn down curve around a well-point; and experiments to determine the pressures on a retaining wall, where the backfill is replaced by a mass of parallel rods, thus avoiding the side-friction.

Cement and concrete research is continuing along fundamental lines. The four principal compounds contained in Portland cement are being tested to determine the contribution of each compound to strength, heat generation, and shrinkage of concrete. Microscopic studies are being made of each compound before and after hardening.

The effects of minute amounts of chemical reagents on the various properties of cement are being investigated to determine to what extent impurities may effect the quality of cement. This is a promising field for study since many cements apparently identical in composition behave differently. Some reagents are found to have a tremendous effect. For example, 0.02 per cent ordinary sugar delays the setting of cement several hours and causes the retarded setting to be more abrupt when it does occur. As little as 0.1 per cent sugar entirely prevents the hardening of cement.

## COURSE X — Chemical Engineering

THE research of Course X is being devoted, in particular, to colloidal chemistry. In an attempt to understand the mechanism of clay behavior, a general research program, which includes, among other techniques, both microscopic and viscosity examinations, is under way. Already these investigations have led to a seemingly satisfactory theory.

Another collodial substance of increasing importance is rubber, which is the subject of a series of investigations. A study of the mechanism of the plasticization of rubber on the rubber mill, an operation which apparently requires both the mechanical working of the rubber and the presence of oxygen, is a specific example of these investigations. A broad program into the mechanism of the setting of cement is also being carried out, this work being done in conjunction with the Department of Civil Engineering's research program on cement.

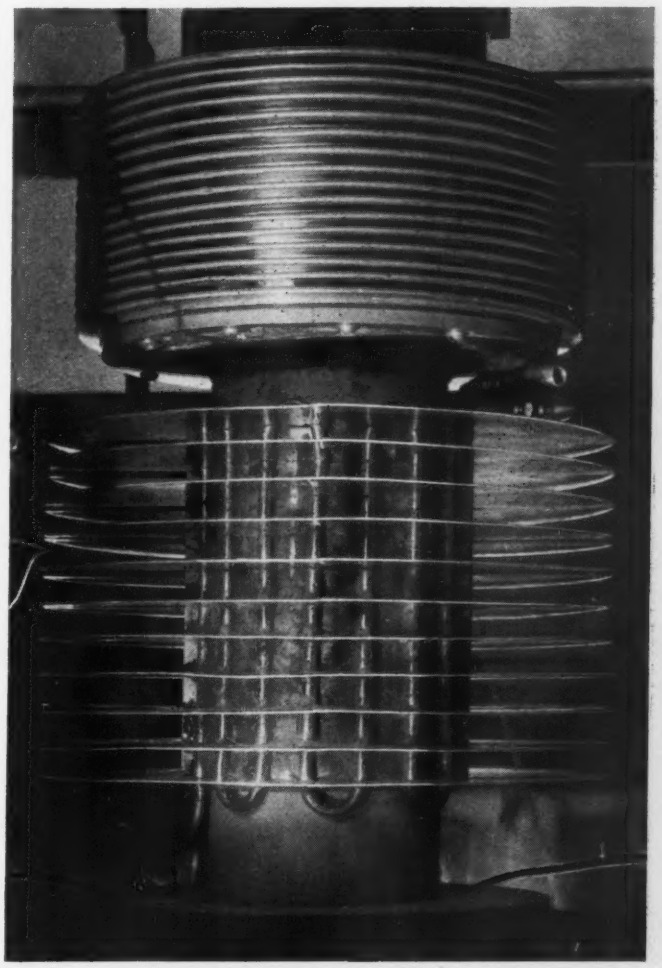
The increasing use of high pressure has been one of the outstanding features of recent developments in chemical industry. A number of investigations are being made into the possibilities of producing desirable organic products by this general technique.

Professor McAdams is studying heat transfer with particular emphasis on the heat transmission from condensing vapors. Recent studies have shown that this heat transmission is several times greater when the condensate coalesces into droplets on the condenser surface than when the condensate spreads in an unbroken film over the surface. Some methods of producing this drop-wise condensation have been indicated. Studies of this phenomenon are being continued.

Further investigations include the performance of rectifying columns in the process of distillation. In fuel engineering, Professor Hottel is continuing his studies of radiant heat transmission, furnace design, and combustion. An extensive program of research on the total radiation from the various gases whose radiation characteristics are important in furnace design has recently been completed.

## COURSE XIV — Electrochemical Engineering

Two papers, based on Course XIV theses of particular interest, were presented at the New Orleans meeting of the Electrochemical Society by Professor Thompson. The first was concerned with the measurement of the decomposition potentials of the oxides of magnesium, calcium, barium, and strontium, dissolved in fused mixtures of fluorides. In those cases where it was possible, the results were checked by thermodynamic calculations, which agreed well with the experimental results. The electrical conductivities were also measured at different temperatures, by an adaptation of the Carey-Foster method. This amounted to the development of a new technique with increased accuracy for the conductivity measurement of fused salts which dissolve all except metal containers. The other paper was a thesis on the Hydrogen Overvoltage and the Anodic Behavior of Tungsten in Aqueous Solutions of Potassium Hydroxide.



*—Bell Laboratories Record*

## ROCKETS

(*Continued from Page 74*)

In shots from point to point, the rocket is aimed high, the calculation being to make the course at the end of the powered flight coincide with a forty-five degree angle, which should theoretically give the greatest distance, not counting air resistance. In really long shots, this point will be reached in the upper atmosphere, or perhaps even outside of it, so that the theoretical maximum will be obtained. There has been so little experience as yet with long point-to-point shots that nothing can be said of the practical application of the ordinary laws of ballistics to rocket flight. At present it seems likely that ballistics will serve admirably to guide the calculation of that part of the flight of a rocket *after* the firing period has built up the necessary momentum. The behavior of the rocket during the powered flight on a long trajectory shot must still be determined experimentally.

*7. Can a living be made out of rocket research?* For the present—alas, no. But a very few years hence, when rockets have been developed to the point of usefulness in weather work and scientific exploration, we may expect to see a rocket industry develop. Then the engineers who have participated in the pioneer work will unquestionably be in line for important positions. Today, however, rocket research is dangerous, rather expensive, time-consuming and without honor except among technically trained men who have imagination as well as education.

This was also true of aviation, not half a lifetime ago.

## DUPRENE

(*Continued from page 71*)

$$HC{=}C{-}CH{=}CH_1 + HCl(+ Cu_2Cl_2) \xrightarrow[\text{catalyst}]{} H_2C{=}C(Cl){-}CH{=}CH_2$$

Chloroprene, as this is sometimes called, boils at 56° C., but rapidly, especially with appropriate accelerators becomes Duprene.

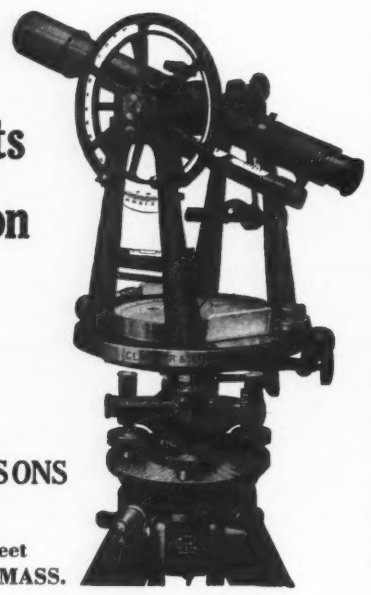
Duprene itself is not affected to any notable extent by aliphatic hydrocarbons, gasoline, kerosene[1], oils, etc. It is very resistant to the action of ozone and hydrofluroic acid. It has nearly twice the abrasion coefficient of ordinary rubber and is the only synthetic rubber that shows Laue diagrams like that of natural rubber. The particle size of "artificial" Duprene latex made by shaking chloroprene with soap solution and ammonia has apparently a smaller particle size since it impregnates porous objects like cloth, leather, tile, wood, increasing their strength notably. Duprene is vulcanized without the use of an autoclave or addition of sulphur. This is effected by heating the X polymer for a few minutes to 114° C.

In strength and resilience, it closely resembles the natural product, but is much heavier. The "machining" of the Duprene is similar to the treatment of natural rubber, but as one can deduce from the foregoing, considerably simpler.

Undoubtedly there will be synthetic rubber produced with other elements than chlorine in combination with various organic groups. Their properties will be interesting to study.

[1]I have specimens of Duprene that have been in kerosene for more than three years and seem as good as when I received them.


**Standard Instruments of Precision**



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## HIGH SPEED ENGINES

(*Continued from Page 75*)

the peak is reached at the point of intersection which would be just at the right hand edge of the graph if the curves in FIG. 11 were prolonged. The limit may be raised by prolonging the horse power or by decreasing the friction axes. Analyses of engine friction discloses t at 45% is caused by the pistons and rings on the cylinder walls, about 25% by other mechanical friction including the bearings, about 30% by pumping losses which is the friction of the air and gas mixture being drawn in through the intake system and being exhausted through the exhausts system. All the frictions are fairly well fixed as the piston ring friction cannot be materially reduced without subsequently reducing the pressure the rings exert on the wall, which would allow the compressed gas to leak past them. Bearing friction cannot be reduced much and is of so small a percentage as not to warrant any discussion here. The limitations in speed caused by the getting of the mixture in and out of the engine is two-fold. The first limitation has already been mentioned as pumping losses, but the second is of greater importance. The size of the valve openings limits the amount of mixture which may be forced in by [the] atmospheric pressure; the shape and size of the manifold, carburetor and valves set a limit on the air flow. Reducing the average velocity of the intake air then is the aim of designers of high speed engines. Air speeds of 150 to 180 ft. per second are desirable and necessary for high speed engines although many engines today have air intake velocity running from 200 to 300 ft. per second. When the openings are too small the volume of the charge of mixture taken into the cylinders falls off and there results a decrease in volumetric efficiency. Volumetric efficiency is defined as the ratio of the volume of mixture taken into the cylinder on the intake stroke (reduced to standard conditions) to the volume of the piston displacement. As engine speeds increase the volumetric efficiency falls off because the air is restricted by the valves. The b. m. e. p. of a clyinder depends upon the amount of charge taken in and since torque is a direct function of b. m. e. p., the torque also declines as speeds are increased. To ma,e high speeds effective the volumetric efficiency must be maintained. Today this is accomplished in two ways; by increasing the size of the intake ports and by super-charging. Increasing the ports has its limitations, however, as will be discussed later, so super charging has come definitely to the fore in high speed engine design. What the supercharger does is force the air gasoline mixture into the cylinder almost irregardless of the size of the openings, by substituting a pressure greater than atmospheric outside the cylinder. Its use first became general when it was discovered that high altitudes affected the power of airplane engines so tremendous-

(*Continued on page 84*)

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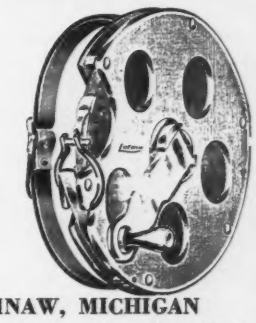

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**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**

## EDITORIALS

(*Continued from page 77*)

a course in physics as something of a necessary evil to be passed and forgotten. Physics should be regarded as an integral and essential part of an engineering education.

If we examine the details of the various branches of engineering, we find the most intimate connections with physics. In considering a few typical examples, we find that civil engineers in designing structures make direct application of the fundamentals of mechanics. Hydraulics is a straightforward utilization of hydrodynamic laws. The mechanical engineers, aside from that part of their work dealing with mechanics and thermodynamics, are feeling more and more the need of a sound knowledge of the structure of metals in connection with the development of better engineering materials. The whole field of electrical engineering is a direct application of that great branch of physics—electromagnetic theory. The aeronautical engineer must delve into the more advanced treatments of hydrodynamics and, in connection with meteorological work, he enters the field of thermodynamics.

And now to the future! There is no doubt that the developments in engineering fields have required an ever increasing knowledge of physical and chemical principles and judging by this fact it is fairly safe to assume that future developments in engineering will be made by those who are well grounded in the fundamental sciences. Furthermore, in any one engineering field there has been a steadily increasing need for a broader education to meet increasingly complicated developments. As an example, we may consider the motion picture industry. Prior to the development of sound pictures, the technical demands of the industry were confined almost solely to specialists in the field of photography. The changes wrought by the introduction of sound effects have been great, acoustical and electrical training being now essential to the engineer in this field. Thus, in this one industry we see the need of men with fundamental training in optics, acoustics, and electrical communications. All in all, there is every reason to believe that the engineer of the future will of necessity require a much broader basic training than in the past.

N. H. Frank,
Associate Professor, Dept. of Physics

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## HIGH SPEED ENGINES

(*Continued from Page 82*)

ly that some drastic means of maintaining a high volumetric efficiency at reduced pressures had to be provided. The Supercharger answered this purpose admirably, and finally found extensive use in the small high speed racing engines already described. In fact, it was due to the supercharger that such high engine speeds at Indianapolis were made possible.

That there are two stock cars in this country selling well within the average price range is a fact not to be overlooked in speculating future developments. The adoption of this auxiliary as standard equipment is but a preliminary step toward boosting speed. It may as well be added that the supercharger of the centrifugal type also aids in districation of the mixture by atomizing the fine particles of gasoline, provided of course that the supercharger is located between the carburetor and the manifold. This is where it is placed on American built cars. In Europe the Roots type blower has found great favor, also a third type called the vane type, which is used on the small M. G. sports car, some of which have been raced on the amateur track at Wayland, Mass. The builders of this car have accomplished a great deal in the field of high speed. With a four cylinder engine of 40 cubic inch displacement they are able to get 120 horse power. This is possible because a speed of 7000 r. p. m. is attained. The vane type blower they use is nearly as large as the engine, but the power necessary to drive it is small compared to the ultimate power output. This power plant weighs about one fifth of what an American engine would weigh of the same horse power and delivers about half the torque so that by using the small engine in the large American car the driving train could be reduced in size materially.

But without going into the field of superchargers there may be still some possibilities. To get back to the discussion of port openings, we must note that all designers are attempting to increase volumetric efficiency. Their efforts have been restricted by use of the single valves because of the limited allowable space in the combustion chamber. Dual valves, that is, two intake and two exhaust, have proved successful although complicated; but even these limit the air intake capacity. Sleeve valves have their restrictions as regards capacity because of their location and the resulting low compression ratio. Rotary valves were used years ago for the entirely different reason that they were quiet. But never were they successful possibly because they never had the development that the poppet valves have had. They may, however, offer great possibilities for future high speed engines because of the large port openings which they can provide—larger than any other type valves known at present. This feature of the rotary may become of sufficient importance as speeds increase to warrant expenditures for their development. It was said not long ago by a British authority that if airplane engine speeds are to be increased and reductions gears used, the use of the poppet valve in that field may have to be abandoned.

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SEVEN HUNDRED WELDS—were needed to make this assembly of aluminum piping.

# New Metals Emphasize Desirability of Jointless Design

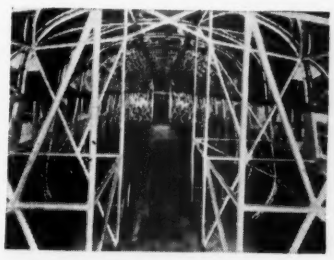
## Welding Preferred Method for Fabricating Jointless Designs from New Materials

*By* **H. E. ROCKEFELLER***

Welding is an important aid in securing the full benefit of the newer light weight alloys, corrosion- and stain-resistant steels and other ferrous and non-ferrous metals. Jointless welded designs in these new metals make the finished product attractive in appearance, efficient and economical to use and enable it to be priced salably.

### In All Industries

Fabrication by welding can be undertaken without heavy capital expenditures and carried out at low cost. Welding is used in every industry for maintenance, for construction and for the fabrication of many products. The welding of mechanical refrigerators and gas ranges is typical of its production applications. Other typical applications include welding of chromium steel for resistance to sea water corrosion on seaplane pontoons, welding aluminum fuel tanks for airplanes, welding of the frame work of alloy steel on the new high speed railroad trains, welding of stainless steel beer barrels and innumerable other familiar products.



HERE'S HOW—the framework of the light weight, streamlined rail cars for high speed is Linde-welded from chrome-molybdenum steel tubing.

### Welding is Simple Production Tool

Welding is the preferred method of fabricating almost every design in modern metals. Jointless welding can be done rapidly with a minimum of preparation of the pieces to be joined. Under procedure control providing jigs for positioning pieces, production can be as rapid and as free from rejections as any highly developed factory process. From the plant equipment standpoint it is easy to adopt welding. From the personnel standpoint the welding technique is quickly acquired through instruction by competent engineers.

### For Jointless Strength and Safety

Products fabricated by welding are jointless, leakproof, permanent and safe. Improved methods of testing make it possible to tell exactly what stresses or loads a jointless welded assembly can take. Metals of different compositions, providing the most suitable material for the service it is to perform, can be welded into sound unified assemblies forever free from any of the losses which occur from joint failures.

### Specialized Welding Assistance

To utilize the new alloys and metals fully, the advice of competent engineers in welded design is advisable. The Linde Air Products Company, a unit of Union Carbide and Carbon Corporation, has for many years specialized in the development of new ways to use oxy-acetylene welding. Linde Engineers will gladly consult with you without obligation, and help you use welding and

IN JIG TIME—using jigs, welded joints can be made quickly in any commercial metal or alloy.

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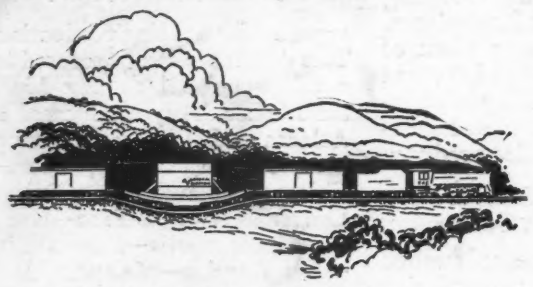
* Engineer, Development Section, The Linde Air Products Company, Unit of Union Carbide and Carbon Corporation.

# G-E *Campus News*

### SYNTHETIC SUNLIGHT

THE people whose apartments faced the lower levels of the ventilating shafts in a 14-story New York apartment house had long ago given up the hope that direct sunlight would enter their windows. Imagine their astonishment one morning not long ago to find light—lots of it—streaming in. When they looked, they found not the sun, but 18 of the sun's able little imitators—General Electric floodlights. They had been mounted on the ninth-floor level.

The engineers were thoughtful of the tenants' feelings. For when the switch is thrown no sudden glare of light paralyzes unaccustomed householders in the act of brushing their teeth or doing setting up exercises, pastimes which were formerly cloaked in intimate gloom. A fully automatic synchronous-motor time switch actuates a dimmer, and the floodlights do not attain full brilliancy for 15 minutes.

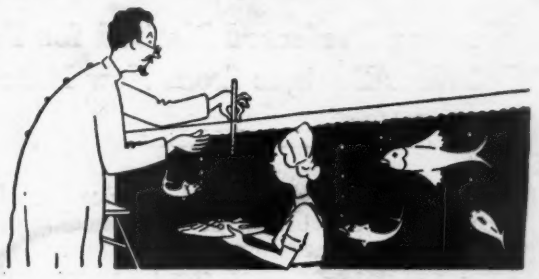


### GROANING RAILS

A FEW weeks ago, the rails between Schenectady and Benning, D. C., groaned under what is believed to be the heaviest load ever transported on a single car. The load consisted of the generator shaft. rotor, and poles for a General Electric frequency-converter set being installed at the plant of the Potomac Electric Light and Power Company to deliver 25-cycle, single-phase power to the Pennsylvania Railroad.

Because of weight and clearance requirements, however, the route of the shipment was round about. A check of practically every foot of the way was made to determine if temporary obstructions could be removed to allow the load to pass. From Schenectady to Wilkes-Barre, Pa., the car traveled on the Delaware & Hudson. From Wilkes-Barre, the car was sent to Hagerstown, Md., on the Pennsylvania Railroad, where it was turned over to the Western Maryland Railroad. After an extensive detour, it was delivered back to the Pennsylvania on its main line just south of the Baltimore tunnels, which were the principal reasons for the complicated routing. From there it was carried directly to the power company's siding in the District of Columbia.

The equipment weighed 367,000 pounds. The special car added another 104,300 pounds, making the total weight on the rails 471,300 pounds.



### FISH LIFE SAVER

THE people in the New York Aquarium were very unhappy. Many of their rare fish were dying of a mysterious malady. An investigation showed that the water pumped into the tanks contained contaminating metal salts, and that these salts came from the metal pumps in the system.

They appealed to the H. A. Smith Pump & Motor Company for help. Mr. Smith began testing all the nonmetallic substances available for making pumps. He tried 14 materials and found that General Electric Textolite was the only one that would prevent this pollution of the water and at the same time make a satisfactory pump.

Engineers of the General Electric Plastics Department were called in, and a new pump was designed, using five different grades of Textolite. The pump was so constructed that no water can come into contact with metal.

96-149DH

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